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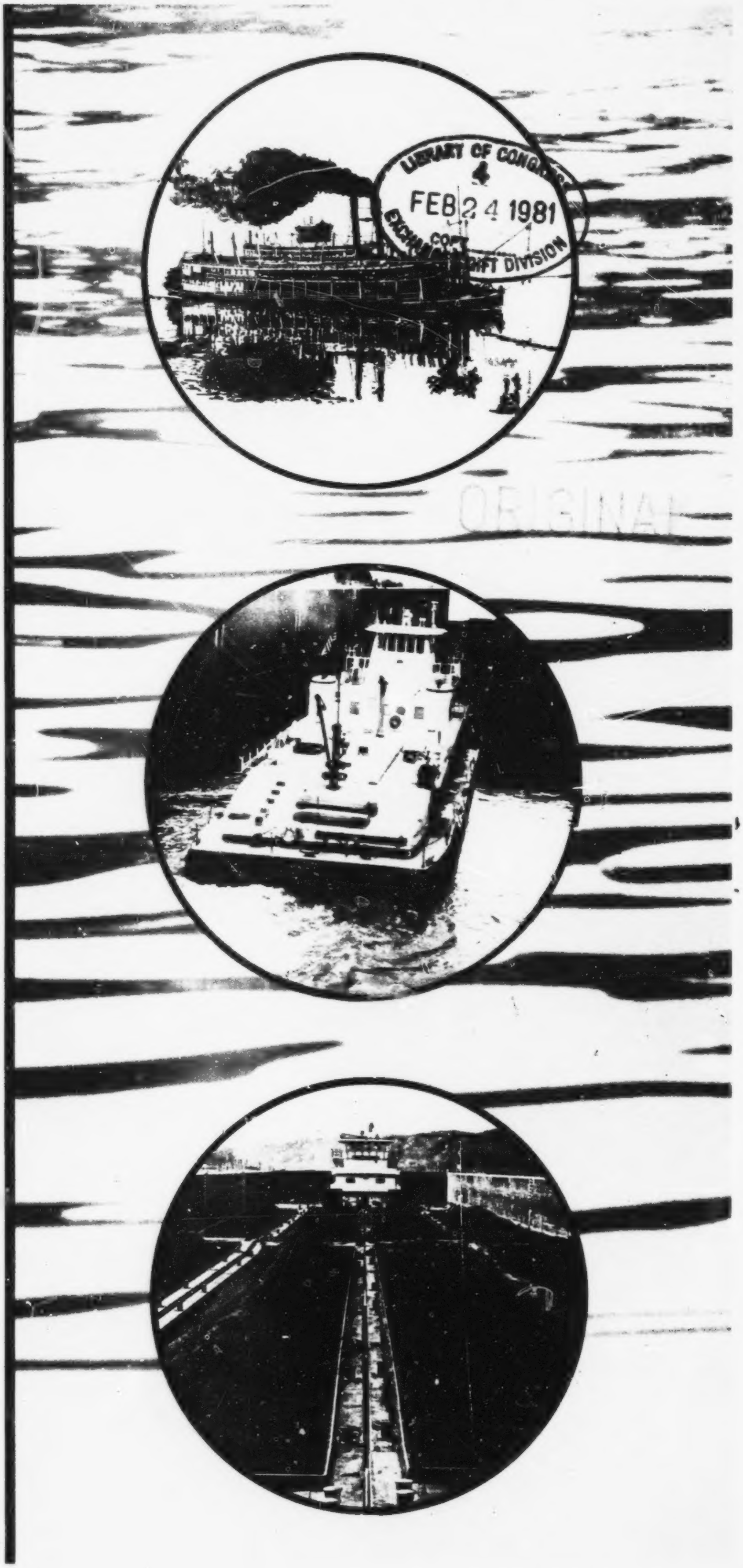
Projections Of Demand For Waterborne Transportation

Ohio River Basin
1980 - 2040

Volume 8

Chemicals and Chemical Fertilizers



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System. Each of the studies considers existing waterborne commerce and develops a consistent set of projects of future traffic demands for all of the navigable waterways of the Basin. Each report contains information on past and present waterborne commerce in the Basin and projections by commodity groups and origin-destination areas from 1976 to at least 1990.

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(Continued from #20)
The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 8 of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

Volume	Subject Title	
1	Study summary	
2	Methodology	
3	Group I:	Coal and coke
4	Group II:	Petroleum fuels
5	Group III:	Crude Petrol.
6	Group IV:	Aggregates
7	Group V:	Grains
8	Group VI:	Chemicals and chemical fertilizers
9	Group VII:	Ores and Minerals
10	Group VIII:	Iron ore, steel and iron
11	Group IX:	Feed and food products, nec.
12	Group X:	Wood and paper products
13	Group XI:	Petroleum products, nec.
14	Group XII:	Rubber, plastics, nonmetallic, mineral, products, nec.
15	Group XIII:	Nonferrous, metals and alloys, nec.
16	Group XIV:	Manufactured products, nec.
17	Group XV:	Other, nec.

Additionally, an Executive Summary is available as a separate document.

Volume 8 of 17

GROUP VI: CHEMICALS & CHEMICAL FERTILIZERS

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN

1980, 1990, 2000, 2020, 2040

Prepared for

U.S. ARMY CORPS OF ENGINEERS
OHIO RIVER DIVISION, HUNTINGTON DISTRICT
Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

DECEMBER 1980

III

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CONTENTS: v.1. Study summary.--v.2. Methodology.--v.3. Commodity groups .

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PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

Subject Title	Number of Pages	Volume Number
Study Summary	220	1
Methodology	118	2
Group I: Coal and Coke	134	3
Group II: Petroleum Fuels	66	4
Group III: Crude Petroleum	42	5
Group IV: Aggregates	64	6
Group V: Grains	131	7
Group VI: Chemicals and Chemical Fertilizers	90	8
Group VII: Ores and Minerals	61	9
Group VIII: Iron Ore, Steel and Iron	104	10
Group IX: Feed and Food Products, Nec.	44	11
Group X: Wood and Paper Products	61	12
Group XI: Petroleum Products, Nec.	38	13
Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec.	41	14
Group XIII: Nonferrous Metals and Alloys, Nec.	57	15
Group XIV: Manufactured Products Nec.	35	16
Group XV: Others, Nec.	48	17

Additionally, an Executive Summary is available as a separate document.

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PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN 1980, 1990, 2000, 2020, 2040

Group VI: Chemicals and Chemical Fertilizers

Prepared for
U.S. Army Corps of Engineers
Huntington District
Contract No. DACW69-78-C-0136

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Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

November 1980

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I. INTRODUCTION

Group VI, consisting of chemicals and chemical fertilizers, accounted for significant volumes of traffic in the Ohio River System (ORS) during the period 1969-76. Of the 15 commodity groups analyzed in this study, chemicals and chemical fertilizers was the fourth largest group in terms of total waterborne traffic. A large portion of Group VI traffic was inbound shipments from outside the System to points within the Ohio River System. More than 21 percent of total inbound movements to the ORS were Group VI commodities and products during the period 1969-76.

The areas within the Ohio River Basin (ORB) for which projections of Group VI consumption, production and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group VI are those U.S. Department of Commerce Bureau of Economic Analysis Areas (BEAs) and area segments (aggregations of counties within a BEA) which are origins or destinations of Group VI waterborne movements. Group VI PSAs are presented in Appendix Map A-1.

In addition to the PSAs, external areas linked to the ORB through waterborne commerce were identified. Areas (BEAs) outside the ORB which are destinations of waterborne chemical and chemical fertilizer movements originating in the ORB are designated as Secondary Consumption Areas (SCAs) Areas (BEAs) outside the ORB which are origins of Group VI waterborne movements destined to the ORB are designated as Secondary Production Areas (SPAs).

A. Description of Group VI

The individual commodities and products included in Group VI are:

Waterborne Commerce Statistics Code (WCSC)	Product/Commodity
2810	Sodium hydroxide (caustic soda)
2811	Crude products from coal tar, petroleum, and natural gas, except benzene and toluene
2812	Dyes, organic pigment, dyeing and tanning materials
2813	Alcohols
2816	Radioactive and associated materials, including wastes
2817	Benzene and toluene, crude and commercially pure
2818	Sulfuric acid
2819	Basic chemicals and basic chemical products, not elsewhere classified (nec.)
2821	Plastic materials, regenerated cellulose and synthetic resins, including film, sheeting, and laminates
2822	Synthetic rubber
2823	Synthetic (man-made) fiber
2831	Drugs (biological products, medicinal chemicals, botanical products and pharmaceutical preparations)

2841	Soap, detergents, and cleaning preparation; perfumes, cosmetics and other toilet preparations
2851	Paints, varnishes, lacquers, enamels, and allied products
2861	Gum and wood chemicals
2871	Nitrogenous chemical fertilizers, except mixtures
2872	Potassic chemical fertilizers, except mixtures
2873	Phosphatic chemical fertilizers, except mixtures
2876	Insecticides, fungicides, pesticides and disinfectants
2879	Fertilizers and fertilizer materials, nec.
2891	Miscellaneous chemical products.

Table 1 presents the waterborne movements of chemicals and chemical fertilizers, by commodity and product, for 1969 to 1976. Significant volumes of waterborne traffic were reported for several of these products. These products have been classified into two categories: industrial chemicals (including miscellaneous chemical products) and agricultural chemicals (Table 2). Other chemical products contributed either minor or no amounts of waterborne traffic to the ORS. Therefore, analysis and projections of Group VI commerce were done only for industrial and agricultural chemicals as categorized in Table 2.

A-1. Industrial Chemicals

For the most part, industrial chemicals are intermediate products which are consumed by industry in the manufacture of final or other intermediate products. This category of chemicals corresponds to Standard Industrial Classification (SIC) Codes 281 (Industrial Chemicals) and 289 (Miscellaneous Chemicals).

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Table 1. Ohio River System: Waterborne Shipments of Chemicals and Chemical Fertilizers by Product, Inbound, Outbound, and Local Movements, 1969-76

(Thousands of tons unless otherwise specified)

Product and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Total	9,914.4	10,833.4	11,520.4	11,406.8	10,538.1	11,612.3	9,360.9	11,364.0	2.0
Inbound	4,309.2	5,022.4	5,584.1	6,145.1	6,051.6	6,715.4	5,525.9	6,353.8	5.7
Outbound	954.0	919.8	1,011.9	1,119.6	895.6	1,031.8	935.9	894.6	(0.9)
Local	4,651.2	4,941.2	4,924.4	4,141.9	3,591.0	3,865.1	2,899.1	4,115.6	(1.7)
Sodium hydroxide	583.9	524.7	544.2	622.8	579.7	575.7	560.3	857.2	5.6
Inbound	117.6	130.4	178.0	170.0	127.1	103.9	110.3	130.6	1.5
Outbound	147.0	133.7	123.5	124.9	149.1	152.0	187.3	223.8	6.2
Local	319.3	260.6	242.7	327.9	303.5	319.8	262.9	502.8	6.7
Crude products from coal tar, petroleum and natural gas	820.5	817.8	918.4	950.6	973.8	1,213.7	910.8	1,275.0	6.5
Inbound	334.7	325.6	416.6	432.2	528.0	529.4	448.6	693.9	11.0
Outbound	205.4	149.6	171.1	190.2	169.8	175.3	138.9	119.2	(7.5)
Local	280.4	341.6	330.7	328.2	276.0	509.0	323.3	461.9	7.4
Alcohols	810.5	873.3	887.1	1,026.2	1,035.1	1,036.2	822.2	923.6	1.9
Inbound	611.6	663.0	669.4	841.8	885.7	907.7	740.0	830.3	4.5
Outbound	90.6	97.3	91.5	81.3	40.2	24.1	20.1	23.7	(17.4)
Local	108.3	113.0	126.2	103.1	109.2	104.4	62.1	69.6	(6.1)
Benzene and toluene	556.1	526.8	426.3	479.3	466.0	558.6	441.1	977.6	8.4
Inbound	469.1	408.3	320.7	319.6	291.2	320.1	217.9	391.5	(2.6)
Outbound	25.9	24.2	23.5	28.3	67.2	81.3	74.2	42.1	7.2
Local	108.3	113.0	126.2	103.1	109.2	156.6	149.0	544.0	25.9
Sulfuric acid	348.1	375.1	306.4	360.3	368.7	355.9	221.7	291.2	(2.5)
Inbound	81.5	103.9	83.1	104.3	106.4	88.6	70.2	87.0	0.9
Outbound	1.2	--	28.6	52.3	21.9	17.1	15.1	8.9	33.1
Local	265.4	271.2	194.7	203.7	240.4	250.2	136.4	195.3	(4.3)
Basic chemicals, nec.	3,959.3	6,841.6	7,351.3	6,808.6	6,269.2	6,805.2	5,281.2	5,496.2	4.8
Inbound	2,343.4	2,891.8	3,261.2	3,709.1	3,670.0	4,172.9	3,267.0	3,170.3	4.4
Outbound	276.1	296.1	351.8	473.1	319.3	365.9	277.7	307.2	1.5
Local	1,339.8	3,653.7	3,738.3	2,626.4	2,279.4	2,266.4	1,736.5	2,018.7	6.0

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Table 1. (Continued)

Product and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Plastic materials	10.0	11.0	3.9	18.0	1.2	2.9	0.7	--	--
Inbound	8.1	10.2	3.9	17.5	--	2.9	--	--	--
Outbound	1.9	--	--	0.5	1.2	--	0.7	--	--
Local	--	0.8	--	--	--	--	--	--	--
Synthetic rubber	21.3	21.8	43.5	60.7	45.7	38.9	38.7	8.9	(11.7)
Inbound	21.3	21.8	43.5	60.7	45.7	37.7	38.7	8.9	(11.7)
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	--	1.2	--	--	--
Paints and varnishes	--	2.7	--	--	1.1	--	--	--	--
Inbound	--	2.7	--	--	--	--	--	--	--
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	1.1	--	--	--	--
Gum and wood chemicals	27.9	24.7	24.1	28.1	22.6	18.5	17.4	22.3	(3.1)
Inbound	27.5	24.7	20.3	21.2	14.5	8.0	8.8	8.9	(14.9)
Outbound	--	--	--	--	--	--	--	--	--
Local	0.4	--	3.8	6.9	8.1	10.5	8.6	13.4	65.1
Insecticides	--	--	--	--	--	1.6	--	--	--
Inbound	--	--	--	--	--	1.6	--	--	--
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	--	--	--	--	--
Dyes, radioactive materials, synthetic fiber, drugs, soap and detergents	--	--	--	--	--	--	--	--	--
Inbound	--	--	--	--	--	--	--	--	--
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	--	--	--	--	--
Miscellaneous chemical products	2,356.3	288.5	339.9	473.6	233.8	228.2	218.5	301.3	(25.5)
Inbound	98.2	139.4	211.3	129.4	40.0	10.6	39.8	81.8	(2.6)
Outbound	--	2.9	2.5	12.2	7.2	18.6	--	1.1	a
Local	2,258.1	146.2	126.1	332.0	186.6	199.0	178.7	218.4	(28.4)

(Continued)

Table 1. (Continued)

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Product and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Nitrogeneous chemical Fertilizers	275.9	262.2	341.5	255.2	275.6	317.1	493.4	536.8	10.0
Inbound	122.0	72.3	142.7	109.3	162.1	265.3	293.1	344.5	16.0
Outbound	135.6	134.3	128.6	83.5	56.6	34.2	161.8	114.0	(2.4)
Local	18.3	55.6	70.2	62.4	56.9	17.6	37.5	78.3	23.1
Potassic chemical fertilizers	1.4	16.9	13.5	18.9	--	0.9	11.3	23.3	49.4
Inbound	1.4	15.4	13.5	17.9	--	--	11.3	23.3	49.4
Outbound	--	1.1	--	1.0	--	0.9	--	--	--
Local	--	0.4	--	--	--	--	--	--	--
Phosphatic chemical fertilizers	10.6	71.8	75.6	46.0	53.9	45.4	37.7	43.9	22.5
Inbound	--	34.0	45.0	34.4	49.9	39.9	37.7	42.8	a
Outbound	10.6	37.8	29.4	10.4	--	5.5	--	1.1	(27.6)
Local	--	--	1.2	1.2	1.2	4.0	--	--	--
Fertilizers and fertilizer materials, nec.	132.5	224.5	244.7	258.2	211.7	413.8	305.9	608.0	24.3
Inbound	72.8	177.9	174.9	177.7	130.9	226.2	241.7	541.2	33.2
Outbound	59.7	42.7	61.4	61.8	63.1	157.0	60.1	53.7	(1.5)
Local	--	3.9	8.4	18.7	17.7	30.6	4.1	13.1	a

Note: Individual items may not add to totals due to rounding.
a. No movements reported in 1969.
Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, 1969-76, supplied by U.S. Army Corps of Engineers.

Table 2. Ohio River System: Total Waterborne Shipments of Chemicals and Chemical Fertilizers, 1969, 1976

(Percentage distribution)

Product	1969	1976
Total	100.0	100.0
Industrial chemicals, (including miscellaneous chemical products)	95.2	89.1
Sodium hydroxide	5.9	7.5
Crude products from coal tar, petroleum and natural gas	8.3	11.2
Alcohols	8.2	8.1
Benzene and toluene	5.6	8.6
Sulfuric acid	3.5	2.6
Basic chemicals	39.9	48.4
Miscellaneous chemical products	23.8	2.7
Agricultural chemicals (excluding insecticides)	4.2	10.7
Nitrogenous chemical fertilizers	2.8	4.7
Potassic chemical fertilizers	a	0.2
Phosphatic chemical fertilizers	0.1	0.4
Fertilizers and fertilizer materials, nec.	1.3	5.3
Other chemicals	0.6	0.3
Plastic materials	0.1	--
Synthetic rubber	0.2	0.1
Paints and varnishes	--	--
Gum and wood chemicals	0.3	0.2
Insecticides, fungicides, pesticides and disinfectants	--	--
Dyes	--	--
Radioactive fiber	--	--
Drugs	--	--
Soap and detergents	--	--

Note: Individual items may not add to total due to rounding.

a. Less than 0.05 percent.

Source: Waterborne Commerce by Port Equivalents, 1969 and revised 1976, supplied by U.S. Army Corps of Engineers.

The wide variety of industrial chemicals and the unavailability of area specific production and consumption data do not permit separate analysis for each chemical. Moreover, constant development and change in the chemical industry requires economic analysis at an aggregate level rather than product specific projections. Therefore, industrial chemicals are defined to consist of four product groups:

- Sodium hydroxide
- Sulfuric acid
- Benzene and toluene
- Other industrial chemicals.

a. Sodium Hydroxide

In 1976, sodium hydroxide (or caustic soda) was ranked sixth in terms of national production levels of the top 50 chemicals.[1] In terms of domestic waterborne commerce, sodium hydroxide accounted for most of the traffic in the chemical and chemical fertilizer group, excluding the broad classification, basic chemicals, nec. In 1976, 10.5 million tons of sodium hydroxide were produced in the United States. Almost 5.0 million tons were shipped by water, a volume equal to 47.6 percent of domestic production.[2] Most of this traffic is not on the Ohio River System but at points near production centers along the Mississippi River and the Gulf Coast.

Sodium hydroxide has many end uses. It is used as a scouring agent and in the manufacture of soap, soluble oils, chemicals and textiles. It has many other applications as well.

This inorganic chemical is usually a by-product of chlorine production from salt. It is shipped in solid, liquid, or bead form.

b. Sulfuric Acid

Sulfuric acid has consistently been the top ranked chemical in terms of production. In 1976, 34.4 million tons were produced in the United States.[1] The equivalent of only 7.2 percent of this production was shipped by water.[2] This small use of water transport resulted from captive use of the chemical in the production of other chemicals, fertilizers, and explosives. The economics of the vertical integration of the product, as well as its corrosive properties, have discouraged increases in the waterborne movements of sulfuric acid.

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[1] "Facts and Figures for the Chemical Industry," Chemical and Engineering News, 12 June 1978.

[2] U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

Sulfuric acid is inorganic and is used in the cleaning and pickling of metals, and in the manufacture of electric batteries, fertilizers, explosives and other chemicals.

Sulfur is oxidized and reacted with steam to form the acid. It is a highly corrosive liquid with high transportation costs. Markets, therefore, are regional rather than national.

c. Benzene and Toluene

Benzene and toluene were ranked 13th and 17th, respectively, in terms of 1976 production of major chemicals. Their combined production in 1976 was over 8,840.0 thousand tons.[3] This excluded production (and consumption) of the products at refineries for the manufacture of gasoline. Approximately two-thirds of toluene production is used for benzene production; most of this is captive use. A large portion of benzene consumption is also captive, used in the manufacture of other chemicals.

In 1976, over 4,741.1 thousand tons of benzene and toluene moved on the Nation's waterways.[4] A large portion of this traffic occurred along the Mississippi River and the Gulf Coast, production centers of the petrochemical industry. Although originally produced from coal tar, these products now are 95 percent petroleum derivatives.

Benzene and toluene are organic chemicals and are colorless, flammable liquids. Virtually all benzene and toluene produced as chemicals is used in the manufacture of other chemicals, such as styrene, cyclohexane, and cumene. These chemicals, in turn, are used in the manufacture of styrenic plastics and rubbers, other plastics, and nylons.

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[1] "Facts and Figures for the Chemical Industry," Chemical and Engineering News, 12 June 1978.

[2] U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol V.

[3] "Facts and Figures for the Chemical Industry," Chemical and Engineering News, 12 June 1978.

[4] U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

d. Other Industrial Chemicals

As defined for this study, "other" industrial chemicals includes the following WCSC classifications:

WCSC Code	Product/Commodity
2811	Crude products from coal tar, petroleum, and natural gas
2813	Alcohols
2819	Basic chemicals, nec.
2891	Miscellaneous chemical products.

This category includes thousands of chemical products including industrial gases such as oxygen and nitrogen; inorganic acids, such as hydrochloric and nitric acids; and petrochemicals, such as ethylene and propylene. A complete listing of the chemicals included in this category is provided in the Appendix.

Of the 50 major chemicals, 41 are included as "other" industrial chemicals. Production of these 41 chemicals was 130.42 million tons in 1976.[1] Approximately 24.4 million tons of the chemicals were shipped by water in 1976.[2]

A-2. Agricultural Chemicals

The individual products included as agricultural chemicals are:

WCSC Code	Product/Commodity
2871	Nitrogenous chemical fertilizers, except mixtures

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[1] "Facts and Figures for the Chemical Industry," Chemical and Engineering News, 12 June 1978.

[2] U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol V.

2872	Potassic chemical fertilizers, except mixtures
2873	Phosphatic chemical fertilizers, except mixtures
2879	Fertilizers and fertilizer materials, nec.

These four products are major components of fertilizer products. Most fertilizer, when applied to cropland, provides three basic nutrients to the soil: nitrogen, potash, and phosphate. Movements of intermediate fertilizer materials are shipments of products providing one basic nutrient or a combination of two or three of these nutrients.

In 1976, these four products accounted for 10.7 percent of total Group VI waterborne commerce (Table 2). Nitrogenous fertilizers and fertilizer materials, nec., are the two principal products in agricultural chemicals. They account for almost 95 percent of the waterborne movements of this category.

a. Nitrogenous Fertilizer Materials

Nitrogenous fertilizers include urea, ammonium nitrate, ammonium sulfate and other nitrogenous materials. Most of these products are derivatives of ammonia. Approximately 75 percent of ammonia production is used in the manufacture of nitrogenous fertilizers.

Over three million tons of this material were shipped on the domestic waterways in 1976.[1] Much of this commerce originated on the lower Mississippi River, where many nitrogen producers are located. Most of this material was urea. Ammonium nitrate, an explosive material, has restricted water transportation; but urea, usually a solid, pelleted material, can be inexpensively stored and moved.

b. Potassic Chemicals Fertilizers

Potassic chemicals include muriate of potash, potassium muriate, potassium sulfate, sulfate of potash magnesia, and vegetable potash. These materials can move by any mode of transportation.

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1. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol V.

Potash is mined in Canada and in the western United States. As such there is no water system which encourages significant use of water for transport of potash. In 1976, domestic waterborne commerce of potassic chemicals totalled 376.8 thousand tons,[1] most of which were coastwise shipments.

c. Phosphatic Chemical Fertilizers

Included in phosphatic chemicals are superphosphates and other phosphate materials. Superphosphates are made by treating phosphate rock with sulfuric acid or nitric acid. Phosphate rock is mined in several southeastern states, principally in Florida. In 1976, domestic waterborne commerce of phosphatic fertilizers totalled 452.1 thousand tons.[2]

d. Fertilizers and Fertilizer Materials, Nec.

Fertilizer and fertilizer materials include diammonium phosphate (DAP), ammonimum phosphates, other mixed chemical fertilizers, and natural animal or vegetable fertilizers. Many of these are produced at the primary nutrient production site and are convenient to water transportation. In 1976, 2,767.0 thousand tons of these materials were shipped on domestic waterways.[3]

B. Existing Waterway Traffic Flows

As illustrated in Table 3, chemicals and chemical fertilizers contribute a substantial portion of waterborne traffic in the ORS. In 1976, Group VI accounted for 5.7 percent of total ORS traffic, the bulk of which was inbound movement. Of the 15 commodity groups analyzed in this study, the inbound shipments for Group VI were second in volume only to Group II, petroleum fuels.

During the period 1969-76, gross waterborne movements of Group VI products were stable. They ranged from 9.4 to 11.6 million tons (Table 1). Over the eight year period, local and outbound movements decreased slightly while inbound movements increased.

B-1. BEA-to-BEA Traffic Flows

During the 1969-76 period, the inbound shipments of Group VI products, consisting of traffic from a port equivalent (PE)

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[1] U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Part V.

[2] Ibid.

[3] Ibid.

Table 3. Ohio River System: Waterborne Shipments of All Commodities and of Chemicals and Chemical Fertilizers, 1976

(Thousands of tons unless otherwise specified)

	Total	Inbound	Outbound	Local
All commodities	200,770.5	29,439.5	26,854.0	144,477.0
Chemicals and chemical fertilizers	11,364.0	6,353.8	894.6	4,115.6
As a percentage of all commodities	5.7	21.6	3.3	2.8

Source: Waterborne Commerce by Port Equivalents, revised 1976, supplied by U.S. Army Corps of Engineers.

outside the Ohio River System to a PE within the ORS increased at an average annual rate of 6.7 percent. This accounted for almost 56 percent of total Group VI movements in 1976.

BEA-to-BEA waterborne flows of chemicals and chemical fertilizers in 1976 are detailed in Table 4. The major BEAs outside the ORS hinterland supplying the PSAs are BEAs 138 (New Orleans) and 141 (Houston). Together, these BEAs accounted for almost 79 percent of the inbound movements of Group VI.

New Orleans shipments originated from points along the Mississippi River between the mouth of the river and Baton Rouge, and from the Gulf Intercoastal Waterway. The major products shipped were basic chemicals, nitrogenous fertilizers, fertilizer materials, nec., alcohols and sodium hydroxide. The majority of BEA 141 (Houston) shipments were from points along the Houston Ship Channel. The major chemicals shipped were basic chemicals, alcohols, benzene and toluene. Both BEA 138 and BEA 141 shipped to points throughout the ORS hinterland.

The three major shipping PSAs, which were also leading chemical producers, were BEAs 52 (Huntington), 64 (Columbus) and 66 (Pittsburgh). These BEAs accounted for over 80 percent of the shipments originating in the ORS (Table 4). Most of the shipments from BEA 52 were shipped from points along the Kanawha River. The products included basic chemicals, sodium hydroxide, miscellaneous chemicals and alcohols. Almost all of the shipments from BEA 64 were basic chemicals shipped from the Willow Island Pool area. The majority of these shipments were received in BEA 52. Most shipments from BEA 66 were from the upper Ohio and Monongahela Rivers. These shipments included crude products manufactured from coal tar, petroleum and natural gas, sulfuric acid, basic chemicals, benzene and toluene. BEAs 52, 64 and 66 supplied BEAs throughout the ORS hinterland and had few or no shipments to points outside the ORS.

Other major shipping PSAs were BEAs 47 (Huntsville) and 115 (Paducah), with shipments of 255.4 thousand tons and 408.7 thousand tons, respectively (Table 4). Huntsville shipped basic chemicals and fertilizer to PEs throughout the ORS. BEA 115 (Paducah) shipments were mostly sodium hydroxide movements which originated near the mouth of the Tennessee River. Over one half of these shipments were sent to BEAs located along the Mississippi and Illinois Rivers.

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Table 4. Ohio River Basin: Waterborne Commerce by BEA, 1976
Group 6: Chemicals and Chemical Fertilizers

(Thousands of tons)

	Destinations														
Origins	Total	ORB BEAs	BEA 47	BEA 48	BEA 49	BEA 50	BEA 52	BEA 54	BEA 55	BEA 62	BEA 64	BEA 66	BEA 68	BEA 115
Total	11,364.0	10,469.4	1,133.4	253.6	489.0	15.6	4,136.2	290.8	764.3	1,298.5	204.1	1,454.8	18.8	410.3
ORB BEAs	5,010.2	4,115.6	103.8	3.1	81.6	0	3,012.0	84.1	33.1	223.4	29.1	467.4	1.0	77.0
BEA 47	255.4	127.6	25.6	1.1	1.1	--	55.0	--	11.9	22.7	--	10.2	--	--
BEA 48	39.9	6.5	--	--	4.5	--	--	--	--	--	--	--	--	2.0
BEA 49	31.4	31.4	--	--	--	--	26.4	--	5.0	--	--	--	--	--
BEA 52	1,146.3	810.8	48.7	--	45.7	--	551.0	16.0	9.0	29.5	--	102.9	1.0	7.0
BEA 54	28.1	17.0	--	--	--	--	7.0	--	--	--	--	--	--	10.0
BEA 55	63.2	23.2	--	--	--	--	--	3.0	5.2	14.0	--	1.0	--	--
BEA 62	65.7	61.5	--	--	1.1	--	36.3	--	2.0	21.1	--	1.0	--	--
BEA 64	1,831.0	1,831.0	--	--	--	--	1,802.0	13.0	--	16.0	--	--	--	--
BEA 66	1,080.4	967.6	10.5	--	2.2	--	494.3	11.1	--	85.1	29.1	330.3	--	5.0
BEA 68	60.1	59.0	--	--	--	--	40.0	--	--	--	--	19.0	--	--
BEA 115	408.7	180.0	19.0	2.0	27.0	--	--	41.0	--	35.0	--	3.0	--	53.0
Non-ORB BEAs	6,353.8	6,353.8	1,029.6	250.5	407.4	15.6	1,124.2	206.7	731.2	1,075.1	175.0	987.4	17.8	333.3
BEA 38	6.7	6.7	--	--	--	--	6.7	--	--	--	--	--	--	--
BEA 39	1.1	1.1	--	--	--	--	--	--	--	--	--	1.1	--	--
BEA 45	15.0	15.0	--	--	--	--	15.0	--	--	--	--	--	--	--
BEA 46	31.2	31.2	--	--	--	--	--	5.6	4.5	21.1	--	--	--	--
BEA 77	83.9	83.9	5.0	--	--	--	71.1	--	--	3.3	--	4.5	--	--
BEA 79	1.1	1.1	--	--	--	--	1.1	--	--	--	--	--	--	--
BEA 91	20.0	20.0	20.0	--	--	--	--	--	--	--	--	--	--	--
BEA 107	8.9	8.9	--	--	--	--	--	2.2	--	6.7	--	--	--	--
BEA 108	6.7	6.7	--	--	--	--	--	6.7	--	--	--	--	--	--
BEA 113	8.9	8.9	--	--	--	--	--	--	8.9	--	--	--	--	--
BEA 114	178.6	178.6	--	--	47.0	--	--	1.1	36.0	11.1	--	48.4	--	35.0
BEA 115[a]	86.8	86.8	--	--	--	--	--	2.2	50.0	31.6	--	--	--	3.0
BEA 134	14.0	14.0	--	--	--	--	--	--	--	14.0	--	--	--	--
BEA 135	16.7	16.7	7.8	--	--	--	8.9	--	--	--	--	--	--	--
BEA 137	309.2	309.2	85.6	16.7	52.3	--	--	--	147.9	6.7	--	--	--	--
BEA 138	2,854.6	2,854.6	36.5	222.6	284.8	--	326.6	73.3	477.8	589.6	130.2	512.4	7.8	193.0
BEA 140	394.9	394.9	23.4	--	1.1	--	196.1	1.1	5.0	71.2	--	97.0	--	--
BEA 141	2,153.1	2,153.1	826.3	10.1	18.9	15.6	406.7	113.4	--	292.8	42.6	315.4	10.0	101.3
BEA 143	121.8	121.8	19.0	1.1	2.2	--	66.0	--	1.1	27.0	2.2	2.2	--	1.0
BEA 144	40.6	40.6	6.0	--	1.1	--	26.0	1.1	--	--	--	6.4	--	--

(Continued)

Table 4. (Continued)

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	Destinations																								
Origins	Non-ORB BEAs	BEA 39	BEA 46	BEA 77	BEA 78	BEA 79	BEA 81	BEA 89	BEA 91	BEA 107	BEA 108	BEA 111	BEA 113	BEA 114	BEA 115[a]	BEA 119	BEA 133	BEA 135	BEA 137	BEA 138	BEA 139	BEA 140	BEA 141	BEA 143	BEA 144
Total	894.6	2.1	123.2	321.1	41.3	27.3	15.6	12.1	4.5	2.2	5.6	5.0	7.8	52.9	3.3	2.0	6.7	1.1	5.0	74.1	3.0	13.7	117.5	39.5	8.0
ORB BEAs	894.6	2.1	123.2	321.1	41.3	27.3	15.6	12.1	4.5	2.2	5.6	5.0	7.8	52.9	3.3	2.0	6.7	1.1	5.0	74.1	3.0	13.7	117.5	39.5	8.0
BEA 47	127.8	--	10.0	44.4	3.3	3.3	--	11.1	4.5	2.2	5.6	--	7.8	4.5	2.2	--	--	--	--	--	--	--	28.9	--	--
BEA 48	33.4	--	--	4.4	13.4	10.0	5.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BEA 49	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BEA 52	335.5	2.1	30.1	140.0	5.6	--	10.0	1.0	--	--	--	--	--	13.2	--	--	--	--	5.0	41.0	3.0	9.5	72.0	3.0	--
BEA 54	11.1	--	--	--	7.8	--	--	--	--	--	--	--	--	1.1	--	--	--	--	--	1.1	--	--	1.1	--	--
BEA 55	40.0	--	--	6.0	3.0	14.0	--	--	--	--	--	--	--	--	--	--	--	--	--	7.0	--	--	--	2.0	8.0
BEA 62	4.2	--	--	--	2.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.0	--	--	--
BEA 64	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BEA 66	112.8	--	14.1	4.3	6.0	--	--	--	--	--	--	--	--	10.1	1.1	--	--	--	--	25.0	--	2.2	15.5	34.5	--
BEA 68	1.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.1	--	--	--	--	--	--	--
BEA 115	228.7	--	69.0	122.0	--	--	--	--	--	--	--	5.0	--	24.0	--	2.0	6.7	--	--	--	--	--	--	--	--
Non-ORB BEAs																									
BEA 38																									
BEA 39																									
BEA 45																									
BEA 46																									
BEA 77																									
BEA 79																									
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BEA 113																									
BEA 114																									
BEA 115[a]																									
BEA 134																									
BEA 135																									
BEA 137																									
BEA 138																									
BEA 140																									
BEA 141																									
BEA 143																									
BEA 144																									

** Traffic external to the Ohio River System **

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a. Waterborne traffic originating from or destined to port equivalents not located in the Ohio River System.

Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

The major receiver of chemicals was BEA 52 (Huntington). It received 4,136.2 thousand tons of chemicals, mostly industrial chemicals, and chemical fertilizers in 1976 (Table 4). Sodium hydroxide shipments to plants along the Kanawha River accounted for about 8 percent of the BEA's receipts. Benzene and toluene were shipped to several PEs along the Ohio and Kanawha Rivers and accounted for only about 10 percent of BEA 52's receipts. The remainder of the receipts was other industrial chemicals, namely basic chemicals, alcohols and crude, products from coal tar, petroleum and natural gas.

BEA 52 (Huntington) received 3,012.0 thousand tons, over 72 percent of its receipts, from BEAs within the ORS. BEA 64 (Columbus) supplied the largest single BEA-to-BEA movement in 1976 (1,802.0 thousand tons) to BEA 52. Because of the large number of chemical plants in or near BEA 52 which produce and consume complementary industrial chemicals, the BEA is not dependent on suppliers from outside the ORS hinterland. In fact, only 28 percent of BEA 52's receipts where shipped from points outside the ORS. BEA 138 (New Orleans) and 141 (Houston) were the major outside suppliers.

On average, BEAs within the ORB provided 40 percent of the receipts of each PSA. In 1976, BEA 66 (Pittsburgh) received 1,454.8 thousand tons of Group VI products. This was almost 13 percent of all ORS receipts, and about 23 percent of those receipts was intra-BEA; that is, shipped from and to PEs in the BEA. Another 9 percent was shipped from other PSAs. Shipments from outside the ORS, however, accounted for the remaining 68 percent of BEA 66's receipts. Over 30 percent of BEA 66's receipts was benzene and toluene, most of which originated along the Gulf Coast. In the PSAs, there are only two major producers of these products -- Ashland Oil and U.S. Steel.

BEA 62 (Cincinnati) received 1.3 million tons of chemicals in 1976. Almost 83 percent originated outside the ORB. BEA 138 (New Orleans) shipped 589.6 thousand tons and BEA 141 (Houston) shipped 292.8 thousand tons to BEA 62 (Table 4). The majority of these shipments was comprised of agricultural chemicals.

BEA 47 (Huntsville) was another major receiving PSA. Almost 91 percent of its receipts was from outside the ORS. Over 800 thousand tons originated in BEA 141 (Houston) (Table 4). This link was the second largest single BEA-to-BEA movement in 1976 and was comprised mostly of petrochemicals shipped to a chemical facility on the Tennessee River.

B-2. Highlights of Waterborne Commerce

Most ORS waterborne movements of Group VI products originated outside the System. These products included petrochemicals and other industrial chemicals manufactured along the lower Mississippi River and on the Gulf Coast. The bulk of the shipments was to chemical plants located in BEAs 52 (Huntington), 66 (Pittsburgh), 62 (Cincinnati), 47 (Huntsville) and 55 (Evansville).

Since most waterborne shipments of chemicals were from waterside producing plants to waterside consuming plants, few intermodal transfers occurred. The exception was agricultural chemicals which were usually shipped to distribution centers. From these distribution points, fertilizers were trucked to fertilizer mixing or blending plants, or to ultimate consumers who received the chemical fertilizers in a form ready for direct application to the soil.

C. Summary of Study Findings

During the period 1969-76, consumption of industrial and agricultural chemicals in the PSAs increased an average of 8.5 percent per year, from 8.7 million tons in 1969 to 15.3 million tons in 1976. Through the year 2000, consumption of industrial and agricultural chemicals is projected to increase at an average annual rate of 3.2 percent. During the period 2000-2040, consumption is projected to increase at an average annual rate of 2.1 percent.

Production of industrial and agricultural chemicals in the PSAs increased from 7.9 million tons in 1969 to 9.9 million tons in 1976, an average annual increase of 3.3 percent. Between 1974-76 and 2000, production is expected to increase at the slightly higher rate of 3.7 percent. During the 2000-2040 period, production in the PSAs is projected to increase at an average annual rate of 2.2 percent.

Gross waterborne shipments are projected to increase from 11.4 million tons in 1976 to 17.7 million tons by 2000, an average annual increase of 2.6 percent. From 2000 to 2040, the average annual increase is projected to be 1.6 percent.

II. MARKET DEMAND ANALYSIS

During the period 1969-76, consumption of industrial and agricultural chemicals in the PSAs increased an average of 8.4 percent per year, from 8.7 million tons in 1969 to 15.3 million tons in 1976. In 1976, 88 percent of this consumption was industrial consumption, primarily by the chemical industry in the production of other chemicals. Through the year 2000, consumption of industrial and agricultural chemicals is projected to increase at an average annual rate of 3.2 percent. During the period 2000-2040, consumption is projected to increase at an average annual rate of 2.1 percent.

A. Market Areas

In addition to local demand for Group VI commodities produced in the PSAs, demand also is generated by Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs which are the destinations of waterborne chemical and chemical fertilizer movements originating in the Ohio River Basin.

A-1. Primary Study Areas (PSAs)

This study has identified 12 BEAs and BEA segments which have been or will be future origins or destinations for Group VI waterborne movements. Appendix Table A-1 and Map A-1 present the BEAs and BEA segments which constitute the PSAs for chemicals and chemical fertilizers for which the consumption of these products has been analyzed and projected.

Over 20 percent of total PSA consumption occurred in BEA 66 (Pittsburgh) during the period 1969-76. The primary metal product and chemical product industries accounted for most of this consumption in BEA 66.

Other major consuming PSAs were BEAs 52 (Huntington) and 62 (Cincinnati). In these BEAs, most consumption of chemicals was accounted for by the chemical industry, which used substantial amounts of industrial high-volume chemicals in the production of other chemicals.

Over 35 percent of the consumption of agricultural chemicals occurred in BEA 55 (Evansville), which includes farming areas of Kentucky, Illinois and Indiana. Other BEAs with large volumes of agricultural chemical consumption were BEAs 49 (Nashville), 54 (Louisville), 62 (Cincinnati) and 115 (Paducah).

A-2. Secondary Consumption Areas (SCAs)

As mentioned earlier, the outbound shipments of Group VI products are insignificant, relative to total traffic. Outbound shipments totalled 894.6 thousand tons in 1976. Much of this tonnage was transported in small quantities to BEAs on the Illinois and Mississippi Rivers.

The largest SCA for waterborne ORS chemicals was BEA 77 (Chicago). It received 321.1 thousand tons in 1976. Of this traffic, 107.9 thousand tons were sodium hydroxide, most of which was shipped from Calvert City, Kentucky in BEA 115 (Paducah) where several chemical companies have sodium hydroxide plants. Most of the other receipts in BEA 77 were basic chemicals (WCSC 2819).

BEA 141 (Houston) received 117.5 thousand tons of chemicals from the ORS in 1976. These were mostly industrial chemicals, shipped from BEAs 47 (Huntsville) and 52 (Huntington).

BEA 46 (Memphis) was the only other SCA which received over 100.0 thousand tons of waterborne chemicals from the ORS. BEA 46 received 123.2 thousand tons in 1976 which were shipped from BEAs 47 (Huntsville), 52 (Huntington), 54 (Louisville), 66 (Pittsburgh) and 115 (Paducah).

BEA 39 (Pensacola) is the most distant SCA from the ORS hinterland. However, shipments to BEA 39 are minor. In 1976, only 2.1 thousand tons of petrochemicals were received, from BEA 52 (Huntington), in BEA 39.

B. Commodity Uses

The chemicals analyzed were industrial and agricultural chemicals. The broad classification, chemicals, does include products such as drugs, soaps, paints and solvents, and plastics. Although these are major categories in terms of dollar value of shipments, they are insignificant products with respect to waterway traffic. This is due to the volumes and distribution networks associated with them. Waterborne traffic is generated almost entirely by high-volume bulk chemical products, sometimes referred to as "commodity chemicals." These commodity chemicals are used primarily as feedstocks in the manufacture of other chemicals which, in turn, are used in the manufacturing and agricultural sectors of the economy.

B-1. Industrial Chemicals

The major uses of industrial chemicals are as inputs for the manufacture of other chemicals, primary metals, textiles, petroleum products, and paper and pulp products. Many industrial chemicals are large tonnage bulk commodities used as "building blocks" in the manufacture of other chemicals and chemical products.

Approximately 50 percent of domestic sodium hydroxide production is used in the chemical industry, mostly in the production of organic chemicals. The pulp and paper industry consumes 15 percent, and the aluminum industry consumes 10 percent of sodium hydroxide production.

The major use for sulfuric acid is the production of phosphoric acid fertilizers, which accounts for approximately 60 percent of sulfuric acid consumption. Over 20 percent of consumption is accounted for by other chemicals, such as titanium dioxide. Other uses include petroleum refining and steel production. The major consumer of sulfuric acid is manufacturing. Approximately 65 percent of domestic production is consumed at the site of production.[1]

Benzene and toluene are used in the manufacture of chemicals and gasoline. However, only benzene and toluene used as chemicals are included in chemical statistics. Two-thirds of toluene is captive production and is used as an input to the manufacture of benzene. Benzene is converted into styrene (through ethylbenzene),

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1. U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports: Sulfuric Acid, 1977 ed. (Washington, D.C.: Bureau of the Census, 1978).

cyclohexane, and cumene. The major end uses of these chemicals are plastics, rubber and nylons.

Other industrial chemicals include inorganic and organic chemicals, such as petrochemicals. These products are used to manufacture other chemicals or are already end-use chemical products supplying various industries. An example of this chain of derived demand is provided in Table 5. It shows industries which are dependent on petrochemicals and some of the products manufactured with petrochemical products.

B-2. Agricultural Chemicals

Agricultural chemicals can be classified into two categories: intermediate fertilizer products and agricultural end-products. Intermediate products are used by the chemical industry in the manufacture of fertilizers. The end-products are processed and suitable for application to crops as fertilizer.

a. Intermediate chemical products

The major end use of agricultural chemicals is as crop fertilizer. The three basic plant nutrients, nitrogen, phosphate and potash, are agricultural end products and are derived from various intermediate product sources.

The basic fertilizer materials industry is interrelated, as derivative products become feedstocks for the production of other chemical fertilizers. Of the three major plant nutrients, nitrogenous and phosphatic fertilizers are manufactured materials. Potash is mined. Anhydrous ammonia, a nitrogenous material, can be used as a fertilizer itself or can be used to make other fertilizer materials. Anhydrous ammonia, most of which is derived from natural gas, is used directly in the production of nitric acid, ammonium nitrate, urea, nitrogen solutions, synthetic ammonium sulfate, and ammonium phosphates (Figure 1). Nitric acid is combined with ammonia to produce ammonium nitrate. Ammonium nitrate, urea, and anhydrous ammonia are used in various proportions to produce nitrogen solutions.

Phosphate rock derivatives include phosphoric acid and the superphosphates. Phosphoric acid is combined with anydrous ammonia to produce ammonium phosphates and with phosphate rock for concentrated superphosphate.

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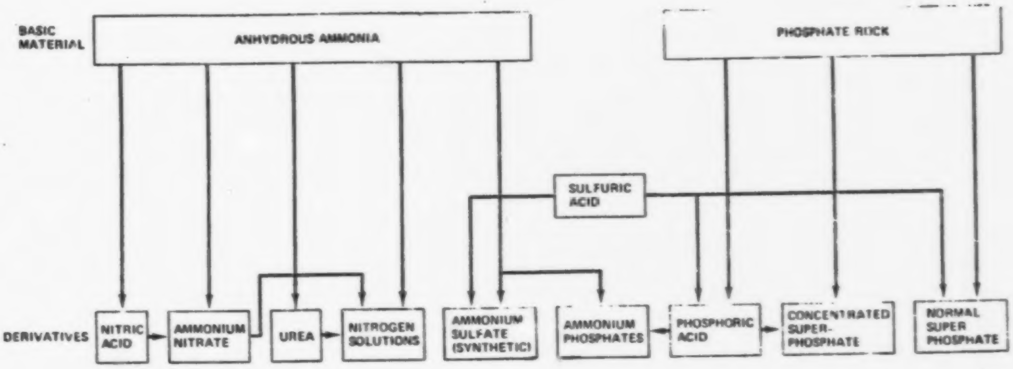
Table 5. Petrochemical Products by Consuming Industries and Typical End Products

Petrochemical product	Consuming industry	Typical end products
Plastics	Coatings Construction Electrical Housewares Packaging Transportation	Containers Plywood Paints Seat covers Wire coating Engineering material
Synthetic fibers	Apparel Carpets Home furnishings Tires	Clothing Rugs Upholstery fabrics Tire cord
Solvents	Dry cleaning Metal working Toilet preparations Printing	Cleaning fluids Personal care items Inks
Surface active agents	Soaps and detergents Mining	Household products Cooper, zinc
Additives	Petroleum refining Transportation	Gasoline Lubricants
Synthetic rubber	Tires Fabricated rubber products	Tires Belting, hose Footwear
Fertilizers	Agriculture	Foodstuffs

Source: U.S. Department of Commerce, Industry and Trade Administration, "Chemicals and Allied Products," U.S. Industrial Outlook, 1979 ed.

Figure 1. Linkages Between Basic Nitrogen and Phosphorous Materials and Their Derivatives


BASIC MATERIAL
ANHYDROUS AMMONIA
PHOSPHATE ROCK
SULFURIC ACID
DERIVATIVES
NITRIC ACID
AMMONIUM NITRATE
UREA
NITROGEN SOLUTIONS
AMMONIUM SULFATE (SYNTHETIC)
AMMONIUM PHOSPHATES
PHOSPHORIC ACID
CONCENTRATED SUPER-PHOSPHATE
NORMAL SUPER PHOSPHATE

Source: U.S. Department of Agriculture, Economic Research Service, The Changing U.S. Fertilizer Industry, August 1977.

Although ammonia, urea and ammonium nitrate are considered fertilizer materials, fairly large quantities are also used for nonfertilizer applications. Between 20 and 25 percent of ammonia is used to make chemical intermediates such as those needed for fibers, plastics and explosives. Other ammonia end uses include various ethanolamines used in treating natural gas to remove unwanted constituents, such as carbon dioxide and hydrogen sulfide, and as a refrigerant in industrial cooling facilities.

Nonfertilizer uses of urea account for about 25 percent of production. Of urea's nonfertilizer uses, animal feed ranks first. Urea's use as a protein-building material in cattle places it in competition with other protein sources, such as soybean meal, and subjects it to the same swings in consumer demand and weather as crops. Urea also is used in the construction industry as an adhesive and as a decorative item. This market experiences strong competition from other materials. Smaller, nonagricultural uses include ureaformaldehyde resins plus other resins containing monomers, such as glyoxal which is applied to paper, textiles, and wood furniture.

Ammonium nitrate is an explosive commonly used in the mining industry. It has largely replaced dynamite. The nonfertilizer and nonexplosive uses of nitric acid, ammonium nitrate's primary feedstock, are many, varied and small relative to the total use. Examples are engraving, the pickling of stainless steels, the manufacturing and reprocessing of nuclear fuels, and the manufacturers of a large number of inorganic and organic chemicals sold in small quantities.

With the market domination by the agricultural sector, overall prospects for agricultural chemicals are little influenced by other uses. Nonfertilizer uses of agricultural chemicals are mature. They have tepid growth rates which are unlikely to have significant impacts on total agricultural chemical demand.

b. Agricultural end products

As indicated earlier, the major end use of agricultural chemicals is as crop fertilizer, and there are three basic plant nutrients. Chemical fertilizers are applied to soils to provide nutrient levels necessary to support the high crop yields essential for profitable crop production.

Because different crops and soils require different quantities and blends of nutrients, fertilizer use varies according to crop and soil characteristics. Nitrogen is the major nutrient used for corn and wheat; potash is the major nutrient used for soybeans.

For the past decade, more fertilizer has been applied to corn than to any other crop. An estimated 88 percent of corn acres which were harvested for grain in 1965 received nitrogenous (N) fertilizer; 82 percent received phosphatic (P_2O_5) fertilizer; and, 77 percent, potassic (K_2O) fertilizer. By 1977, these percentages had grown to 96, 88, and 82, respectively. The rate of primary nutrient application per acre of corn which was fertilized also increased dramatically in the period 1964-77. The corn that was fertilized in 1965 received an average of about 75, 50 and 48 pounds per acre of N, P_2O_5, and K_2O, respectively. By 1977, these rates had increased to 128, 68 and 82. Future increases in the pounds of N, P_2O_5, and K_2O which are applied to corn are expected to be significantly smaller than in the past. This is because the large percentages of corn have already been treated, and because fertilizer application rates are reaching saturation levels. Further farmer introduction to, and education regarding fertilizer will result in more economic applications of fertilizers.

Wheat, the second major grain crop of the United States in terms of acreage and total amounts of fertilizer used, accounts for less than one-fourth as much fertilizer as is used for corn. Soybeans are the least fertilized major grain crop, with approximately one-third of soybeans harvested receiving P_2O_5 or K_2O, and less than one-fourth receiving nitrogen. Growth in pounds of N, P_2O_5, and K_2O applied to wheat will occur as a growing percentage of planted acres are fertilized. Growth in application to soybeans will also result as more acres are planted.

C. Consumption Characteristics

The major consumption characteristics of Group VI products may be divided into three broad categories: economic, technological, and institutional characteristics. The discussion which follows analyzes how each of these sets of characteristics impacts on the consumption of industrial and agricultural chemicals.

C-1. Industrial Chemicals

Chemicals are used in virtually every industry. As industries develop, new chemical products are found, distribution patterns are altered and other chemical products are replaced. However, a distinction can be made between high-volume bulk chemical commodities and specialty chemicals. The demand for chemical commodities reflects the economic condition of the nation. As stated at a symposium sponsored by the American Chemical Society, "These (inorganic and heavy chemicals) are basic building blocks for the whole chemical and processing industries, and the growth curves for the consumption of these products reflect the economic health of our country."[1]

a. Economic characteristics

The demand for industrial chemicals is derived from the demand for the products of the industries which consume the chemicals. For example, the demand for chlorine and sodium hydroxide declined in 1975 as a result of downturns in the construction, automotive and aluminum industries. The major consuming industry is the chemical industry, whose growth has been impeded by inflationary pressures, environmental regulations, and reduction in capital expenditures which may lead to supply shortages.

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1. W.F. Newton, "Inorganic and Heavy Chemicals," Chemical Marketing: The Challenge of the Seventies (Washington, D.C.: American Chemical Society, 1968), p. 15.

The chemical industry is the major industrial user of energy. In 1974, the industry accounted for 22 percent of total manufacturing consumption of energy (excluding petrochemical feedstocks). Feedstocks such as petroleum products and natural gas are consumed in substantial amounts which exceed the chemical industry's basic energy requirements. This has led to substantial increases in the cost of production and the price of chemicals to industry. Although there has been some attempt to find alternatives to chemical products tied to energy sources, industry will most likely continue to rely on existing products but at lower levels of consumption. These energy dependent chemicals are used in the manufacture of high value products; their producers can pass these costs to the ultimate consumer. Although there will be short-run shortages in feedstocks, the chemical industry should be able to compete successfully for energy.

Another factor impacting on price is government regulation. It has been estimated that the costs of meeting Occupational Safety and Health Administration (OSHA) regulations will account for 12 percent of annual production costs in the chemical industry.[1] Pollution abatement regulations, relating to clean air, clean water and solid waste disposal, have and will continue to add costs to the industry. Capital expenditures for pollution abatement currently represent 10 percent of total capital expenditures by the chemical industry. This compares with a 5.5 percent average for all industry.[2] Although there has been some government recognition of the negative impact that these regulations could have on the chemical industry, and those industries dependent on chemicals, substantial amounts of capital will still be required to meet government standards in the future.

During the period 1969-76, wholesale prices of industrial chemicals increased at an average annual rate of 11.8 percent, versus 8.0 percent for all commodities.[3] This price increase did not seriously impede growth in the chemical industry.

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1. U.S. Department of Commerce, Industry and Trade Administration, U.S. Industrial Outlook, 1979 ed. (Washington, D.C.: GPO, 1979), p. 126.
2. Ibid.
3. U.S. Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics, 1977 ed. (Washington, D.C.: GPO, 1977).

b. Technological characteristics

The chemical industry is characterized by a high rate of technological innovation. A substantial portion of chemical sales can be attributed to products which have been developed within the past 20 years. The development of many of these products has resulted in the obsolescence of other chemicals. However, since these chemicals usually remain the raw materials used in the production of new specialty chemicals, innovation has not impaired the consumption of basic industrial chemicals. Across all industries, as estimated by the U.S. Department of Commerce, technological innovation contributed 45 percent of the Nation's economic growth from 1929 to 1969.[1]

In addition to new product developments, research in the chemical industry has developed new uses for existing products; thus, it has expanded the market for chemicals. A prime example of this is nylon.

A major concern to the chemical industry is the cost of research and development to meet environmental controls. In 1976, approximately 5 percent of the chemical industry's expenditures on research and development was spent on projects relating to pollution abatement.[2] These expenditures are diverted from product development and may slow the rate of growth in the chemical industry.

c. Institutional characteristics

Government regulations have had a direct impact on the consumption of certain chemical products. Such regulations include proposals to limit the sale of phosphate-based detergents in the Great Lakes area, the Toxic Substances Control Act of 1976[3] (which may eliminate use of potential carcinogens such as benzene), bans and possible bans of a number of chlorinated chemicals, and Environmental Protection Agency (EPA) actions to curtail the use of flurocarbons for propellant purposes.

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1. "Vanishing Innovation," Business Week, 3 July 1978.
2. U.S. Department of Commerce, Industry and Trade Administration, U.S. Industrial Outlook, 1979 ed. (Washington, D.C.: GPO, 1979), and "Vanishing Innovation," Business Week, 3 July 1979.
3. P.L. No. 94-469, 15 U.S. Code § 2601, October 11, 1976. For further discussion see Section III B-3 of this report.

C-2. Agricultural Chemicals

In terms of absolute amounts, and relative to production of agricultural products, the consumption of agricultural chemicals has expanded during the last decade. This has occurred in response to export demand and in response to the relationship between fertilizer costs and crop yields, relative to fertilizer application rates, and the prices for agricultural products.

Projections of the demand for agricultural chemicals require an analysis of the major characteristics influencing demand. These characteristics are discussed below.

a. Economic characteristics

Primary plant nutrients can be applied to the soil through direct application or in mixed, or diluted, form. Since producers have become input oriented, transportation costs have had a greater impact on the prices farmers are willing to pay for fertilizer. As a result, increasing amounts of nitrogen fertilizer are being consumed as direct application materials. Farmers have shifted their preferences from the lower analysis (less nutrient content per unit of material) fertilizers, such as ammonium nitrate, to high analysis (low cost per unit nutrient products), such as nitrogen solutions. However, as natural gas feedstock costs increase, increases will occur in the production costs of nitrogen and in costs to consumers.

Industry changes are based on changes in demand for the product. Short-run, cyclical supply-demand imbalances are frequent. When supply exceeds demand, plants close. Record application rates and increases in acres planted have resulted in an expansion of domestic fertilizer production. Rising imports have also increased fertilizer supply. These supply increases, coupled with railcar shortages and dampened demand, have resulted in a weakening of prices.

Fertilizer demand is becoming more responsive to export demand and farmer net income. The 1970s saw substantial change in the overall demand picture as average annual increases in demand dropped substantially, relative to the 1960s. The underlying long-term growth rate is no longer strong enough to override short-run depressants such as weather, changing governmental policies, and fertilizer-crop and fertilizer-income price ratios. Farmers have, in the recent past, responded to unfavorable agricultural commodity-fertilizer price relationships by reducing fertilizer purchases by 10 percent. Should farmers become more responsive to declining exports by reducing plantings, the rate of growth in fertilizer use would slow.

b. Technological characteristics

The technological issues regarding chemical fertilizer consumption center around storage design, handling, transport, and application. Work is being done in the field to reduce fertilizer loss from soil surfaces. Innovations in containerization, and the reduction of costs and losses in transloading, are effecting the bulk movement of fertilizers. More efficient and less labor intensive means of removing solids from storage are lowering handling costs. Storage design innovations oriented toward the utilization of a larger percentage of building volume are being adopted.

The most dramatic change in fertilizer application technology is the high flotation, high capacity applicator for fluid and granular fertilizers. It can apply 300 to 700 pounds per acre at a rate of one acre per minute.

c. Institutional characteristics

The principal marketing pattern of the 50 million tons of fertilizer distributed annually in the United States consists of 90 primary nutrient producers which distribute chemical fertilizer to about 100 granulation plants, 5,000 bulk blenders and 1,700 liquid and suspension mix plants. Blending services are not mutually exclusive, and any one blender may provide all three services. These intermediate processors distribute about 90 percent of the 50 million tons to 12,000 retail distributors who provide fertilizer to farmers. In addition, these retail distributors offer such services as spreader rental, soil testing, custom blending of pesticides, and micronutrients and seeds with mixtures.

Bulk blending is the largest single system of manufacturing and distributing fertilizer mixtures. It accounts for almost half of the total market for all fertilizers sold to farmers. Because of its simplicity, economy, and capability in providing farmers with desired services, this method of blending and distribution has grown rapidly. Bulk blending does not change the chemical nature of the ingredients. Materials which are most commonly used for bulk blending are ammonium nitrate, urea, ammonium sulfate, diammonium phosphate, granular triple superphosphate, and potassium chloride. By combining several products, bulk blending permits all three primary nutrients to be applied at one time. The typical bulk blender is small. It will produce and market only 2,000 to 6,000 tons a year within a 10 mile market radius.

Liquid and suspension mix plants sell an average of 1,000 to 2,000 tons of fertilizer per year. A base solution of 10-34-0, is produced by neutralizing nitrogenous solutions and potassium chloride in water. Fluid fertilizers provide two advantages: ease in incorporating additives and ease in securing mixture homogeneity.

Granulation plants require large capital investments and production levels. They sell between 50,000 and 100,000 tons of fertilizer per year. The conventional chemically mixed fertilizer granulation plant uses ammonia, nitrogen solutions, and ammonium sulfate as its principal nitrogen sources; it uses phosphoric acid and the superphosphates as its principal phosphatic (P_2O_5) sources. Granulation plants supply materials to bulk blenders.

The distribution systems of the bulk blender and the liquid and suspension mixer provide an economical way of combining the intermediate fertilizer materials which are produced at widely divergent production points. They provide market area storage facilities and dealer-farmer distribution links.

The three blender/distributor types can have cooperative, independent, producer-owned, or franchised forms of business.

The fertilizer distribution and marketing pattern applies in all regards to the area served by the Ohio River System. The distribution of the three blender/distributor types across the states which contain areas in the PSAs is presented in Table 6.

Government regulation impacts upon chemical fertilizer consumption in two ways. Government acreage restrictions, in terms of set-aside programs, have traditionally had limited short-run effects on total fertilizer consumption. Given the underlying rapid growth in application rates, acres planted, and percentage of planted acres fertilized, such acreage limitations are scarcely felt. These elements of demand have overriden the reductions in use which otherwise would have resulted from restrictions.

Table 6. Ohio River Basin: Number of Fertilizer Plants by Type and State

	Bulk	Granulation	Liquid and suspension
Primary Study Areas[a]	190	11	89
Alabama	0	1	6
Illinois	15	0	19
Indiana	32	2	17
Kentucky	110	4	34
Maryland	2	0	0
Ohio	17	0	10
Pennsylvania	5	1	0
Tennessee	6	3	3
West Virginia	3	0	0

[a] State data is the sum of plants located in Primary Study Areas only and not the total for each plant type for an entire state.

Source: Tennessee Valley Authority, National Fertilizer Development Center, Directory of Fertilizer Plants in the United States - 1976, Bulletin Y-114, June 1977.

There are environmental problems related to the storage, handling, shipment and application of chemical fertilizer. Liquids require storage safeguards that provide adequate diked enclosures which are, in the event of a massive rupture or spill, capable of containing the entire contents of tanks. Solid material storage and handling requires fugitive dust control. The shipment of fertilizer intermediates requires safeguards against massive leakages. Regulatory agencies now require two-shelled (double bottomed) barges in the movement of liquid fertilizer materials. In the application of fertilizer, the main concern is the prevention of surface-applied material from washing into streams, and of soluble nutrients leaching out into ground water or streams.

d. Climatic characteristics

In the short run, abnormal weather may bring about unexpectedly large changes in total fertilizer use. Unfavorable spring weather can delay fertilizer application and, under some conditions, can cause farmers to choose to plant soybeans rather than corn. Fertilizer consumption would, thereby, be reduced.

D. Existing Aggregate Demands

During the period 1969-76, domestic consumption of the major industrial and agricultural chemicals increased from 192.1 million tons to 232.2 million tons, an average annual increase of 2.7 percent.[1] Consumption of agricultural chemicals increased at an average annual rate of 3.4 percent, while industrial chemical consumption grew at a less rapid average annual rate of 2.6 percent. In 1976, consumption of major industrial chemicals and agricultural chemicals totalled 183.1 million tons and 49.1 million tons, respectively.

In the PSAs, total consumption of industrial and agricultural chemicals increased from 8,672.1 thousand tons in 1969 to 15,263.2 thousand tons in 1976, an average annual increase of 8.4 percent (Table 7). The consumption of industrial chemicals grew at an average annual rate of 8.8 percent from 1969 to 1976, while the consumption of agricultural chemicals increased at the less rapid rate of 6.6 percent. This increase reflects the industrial growth which has occurred in the PSAs during the past decade.

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1. "Facts and Figures for the Chemical Industry," Chemical and Engineering News, 12 June 1978; and U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, Commercial Fertilizers (Washington, D.C.: USDA, 1977).

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Table 7. Ohio River Basin: Consumption of Industrial Chemicals and Agricultural Chemicals, by BEAs or BEA Segments,[a] Estimated 1969-76

(Thousands of tons unless otherwise specified)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Primary Study Areas	8,672.1	9,705.1	10,501.9	10,901.6	11,711.9	13,895.5	12,605.8	15,263.2	8.4
BEA 47: Huntsville, AL	438.7	482.9	537.5	533.7	608.2	782.4	720.7	914.3	11.1
BEA 48: Chattanooga, TN	846.1	904.0	948.0	965.9	1,027.2	1,176.9	1,014.0	1,245.5	5.7
BEA 49: Nashville, TN	804.9	867.8	931.0	937.5	1,000.8	1,161.1	1,025.3	1,290.0	7.0
BEA 50: Knoxville, TN	138.3	266.9	389.4	508.4	648.5	854.7	821.1	1,105.3	34.6
BEA 52: Huntington, WV	1,182.8	1,241.0	1,340.8	1,361.7	1,300.9	1,512.6	1,299.6	1,455.1	3.0
BEA 54: Louisville, KY	807.0	877.0	922.6	921.1	1,011.9	1,239.9	1,088.0	1,330.5	7.4
BEA 55: Evansville, IN	606.0	702.0	683.1	710.9	760.5	888.5	826.7	1,064.3	8.4
BEA 62: Cincinnati, OH	1,389.7	1,548.8	1,612.6	1,614.6	1,734.3	1,920.5	1,722.4	2,035.2	5.6
BEA 64: Columbus, OH	478.4	588.3	695.2	757.6	794.5	950.7	872.8	1,048.8	11.9
BEA 66: Pittsburgh, PA	1,679.8	1,891.4	2,070.3	2,207.7	2,393.4	2,877.2	2,692.2	3,085.6	9.1
BEA 68: Cleveland, OH	29.4	32.2	31.1	32.7	32.8	36.4	35.0	40.9	4.8
BEA 115: Paducah, KY	270.7	302.8	340.3	349.8	398.9	492.6	488.0	646.7	13.2

Note: Historical consumption data for industrial chemicals, 1969-76, were derived from production of the top 50 chemicals, in Chemical and Engineering News. In addition to the weekly Chemical and Engineering News, the American Chemical Society publishes Key Chemicals, The Basic Products of the Chemical Industry. This publication explains different industries' need of key chemicals. These chemicals are mainly used by industries producing chemical and allied products, textile products, paper and allied products, petroleum refining products, primary metal products and miscellaneous manufacturing products. After estimating each industry's total national requirement for sulfuric acid, benzene and toluene, sodium hydroxide, and all other industrial chemicals separately, the consumption by each industry by BEA and BEA segment was estimated according to the ratio of employment in each BEA and BEA segment to the national employment in each industry. Thus the consumption data were derived for industrial chemicals. Chemical fertilizer consumption was derived by the multiplication of harvested acres of corn, wheat and soybeans by BEA and BEA segment times the fertilizer application rates (nitrogenous (N), phosphatic (P_2O_5), and potassic (K_2O) primary nutrient pounds) for corn, wheat and soybeans times the percent of harvested acres receiving fertilizer times a factor for acres planted and fertilizer but not harvested times the tons of fertilizer material necessary to provide one ton of primary nutrient. Fertilizer material tons were derived by dividing the estimated domestic supply (domestic production + imports - exports) of N, P_2O_5 and K_2O chemical materials by the average analysis (i.e., the percentage of primary nutrients contained per unit of chemical material).

a. BEA segments are defined as counties which are ultimate origins or destinations of waterborne movements.

Source: National production data for major chemicals and industrial requirements from "Facts and Figures for the Chemical Industry," Chemical and Engineering News, 1969-78 eds. County and state employment data from the U.S. Department of Commerce, Bureau of the Census, County Business Patterns, 1970-76 eds. National employment by industry from the U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, 1909-1975, and recent updated data. Nitrogenous, potassic and phosphatic chemical fertilizer material estimated domestic supply for fertilizer use from U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, The Fertilizer Supply,

(Continued)

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Table 7.(Continued)

1968-1979 and 1977-1978. Average analyses from U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, Commercial Fertilizers, Final Consumption for the Year, ended June 30th 1976. Fertilizer application rates and the percent of acres receiving fertilizer for 1969 from U.S. Department of Agriculture, Statistical Reporting Service, Cropping Practices, 1964-70 eds. and for 1971-76 from U.S. Department of Agriculture, Economic Research Service, Fertilizer Situation, 1975 and 1978 eds.

BEA 50 (Knoxville) experienced the most rapid growth in chemical consumption during the period 1969-76, with an average annual increase of 34.6 percent. Most of this growth was due to the increase in industrial consumption. Other PSAs with substantial increases in chemical consumption were BEAs 115 (Paducah), 64 (Columbus), 47 (Huntsville) and 66 (Pittsburgh).

More than 20 percent of the chemical consumption in the PSAs occurred in BEA 66 (Pittsburgh) during the period 1969-76. The primary metal products industry was a major consumer of chemicals in Pittsburgh, as was the chemical industry. Other PSAs with substantial quantities of industrial chemical consumption were BEAs 62 (Cincinnati) and 52 (Huntington).

The major consumer of agricultural chemicals was BEA 55 (Evansville). Of the 1,064.3 thousands tons of chemicals consumed in the BEA in 1976, almost 62 percent was agricultural chemicals. During the period 1969-76, consumption of agricultural chemicals increased at an average annual rate of 5.5 percent in BEA 55. This was a reflection of the increase in land used in the production of major crops.

BEA 49 (Nashville) was another major consuming PSA of agricultural chemicals. Of the 1,290.0 thousand tons of chemical consumed in the BEA in 1976, 23.4 percent was agricultural chemicals. During the period 1969-76, consumption of agricultural chemicals increased at an average annual rate of 8.8 percent in BEA 49. During this period, corn acreage in BEA 49 increased from 373.3 thousand acres to 536.3 thousand acres; wheat acreage, from 121.7 thousand acres to 217.4 thousand acres; and soybean acreage, from 94.4 thousand acres to 456.1 thousand acres.[1] The growth in volume of agricultural chemical consumption would have been even greater but for the shift toward more concentrated fertilizers.

BEA 115 (Paducah) consumption of agricultural chemicals increased at an average annual rate of 10.6 percent between 1969 and 1976. Substantial increases in acreage, production and yields were reported for this period in BEA 115.

E. Forecasting Procedures and Assumptions

Separate projections were developed for industrial and agricultural chemical consumption. Projections of industrial chemical consumption were based on OBERS projections of industrial activity, developed by the U.S. Department of Commerce for the U.S. Water Resources Council. Projections of agricultural chemical consumption were based on projections of acreage by crop which were developed for Grains (Group V) Report, and on projected fertilizer application rates estimated by the Tennessee Valley Authority.

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[1] Grains (Group V) Report.

E-1. Industrial Chemicals

National production of major industrial chemicals was estimated separately, from information obtained from the American Chemical Society, for sulfuric acid, benzene, toluene, sodium hydroxide, and other industrial chemicals for the period 1969-76. Consumption by industry was estimated from data on the distribution of consumption among market industries.[1] It was adjusted for foreign trade. National consumption, by industry, was distributed among PSAs using the distribution of national employment in each of these industries among the PSAs. Employment data were the best available historical county level data which could be aggregated into the PSAs. They provide some measure of regional versus national economic activity for the industries which were examined. Projections of consumption were estimated by using the historical consumption by PSA and industry and by applying BEA growth rates in earnings by industry. These growth rates were prepared by the U.S. Department of Commerce for the OBERS Projections, Series E, published by the U.S. Water Resources Council.

Growth rates in earnings in each PSA were assumed to be equal to the growth rate in the appropriate BEA. No projections of industrial activity beyond the year 2020 were identified. Therefore, based on the assumption that constraints to growth become more pronounced as growth occurs, a decrease in the experienced rate of change in the period 2000-2020 was assumed. Growth rates, by industry, for the period 2020-40 were assumed to be equal to half of the rates projected for the period 2000-2020.

This assumes that consumption of industrial chemicals by each industry will increase at the same rate as earnings (in constant dollars) for that industry. Growth in earnings does account for some of the expected changes in worker productivity, a factor that would not have been included in employment growth rates. Also,

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1. Major consuming industries include chemical and allied products, textile products, paper and allied products, petroleum refining products, primary metal products, and miscellaneous manufactured products.

since the chemical product types consumed may vary in the future, these products were assumed to substitute for one another on a one-to-one volume basis.

E-2. Agricultural Chemicals

Chemical fertilizer applied to an acre of any crop is reported in primary nutrient terms. This means that the "fertilizer application rate" reflects the amount of N, P_2O_5, and K_2O that an acre of corn, wheat or soybeans receives. However, as none of the nitrogenous, phosphatic, or potassic chemical fertilizer materials are pure (i.e. 100 percent N, P_2O_5 or K_2O), it requires more than one unit of any fertilizer material for the soil to receive one unit of N, P_2O_5 or K_2O. An average analysis of fertilizer materials (i.e. the percentage of primary nutrient contained per unit of chemical material) was used in order to derive the number of units of any one fertilizer material which is needed to yield one unit of primary nutrient. Since it is the fertilizer materials which are transported (anhydrous ammonia, triple superphosphate, etc.) and not the primary nutrients, this analysis was performed in order to more accurately reflect the actual amount of chemical fertilizer tonnage moved by any one mode of transport.

The procedure and assumptions used in estimating future consumption are outlined in Table 8. As there are three crops and three primary nutrients, nine separate sets of calculations were performed for each PSA.

On the average, agricultural chemicals account for between 4 and 6 percent of future total chemical consumption. This is lower than in the past because of the faster growth in consumption of other chemicals and the decline in harvested corn acres. Corn is the most heavily fertilized crop.

F. Probable Future Demands

Consumption of chemicals in the PSAs is projected to increase at the rate of 3.2 percent between the period 1974-76 and 2000 (Table 9). This growth will occur in the consumption of industrial chemicals, while the net change in agricultural chemical consumption will be insignificant. Agricultural chemical consumption will actually be less than the 1970s levels in the years 1980 and 1990. This will result from the expected shift in acreage from corn to soybeans. Soybean production requires substantially less fertilizer material per acre than corn production.

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Table 8. Ohio River Basin: Summary of Consumption Projection Methodology for Agricultural Chemicals

Total chemical fertilizer consumption = Corn, wheat or soybeans acres harvested by BEA and BEA segment X Tons of fertilizer materials consumed per acre of corn, wheat or soybeans planted and harvested

Tons of fertilizer material consumed per acre of corn, wheat or soybeans planted and harvested = Fertilizer application rate in pounds per acre harvested of corn, wheat and soybeans X Percent of harvested acres receiving fertilizer X Factor for acres planted and fertilized but not harvested X Pounds of fertilizer material necessary to provide one unit of primary nutrient ÷ 2,000 pounds per ton

Variable	Basis for projection	Procedure/assumptions
Fertilizer application rate	Projections from Fertilizer Institute, Third World Conference Proceedings, "Musings on the U.S. Fertilizer Industry, 1990" (Remarks of Dr. John Douglas, Assistant to the Manager, Tennessee Valley Authority), September 1978.	National rates applied to ORS hinterland. 1980 derived by applying 1976-85 growth rate to 1976 base. Rates assumed constant after 1990.
Percent of harvested acres receiving fertilizer	(As above)	(As above)
Acres planted and fertilized but not harvested	Derived from the U.S. Department of Agriculture, Agricultural Statistics, 1977 ed. The average of the ratio of acres harvested to acres planted for the primary consumption area states.	Historical average assumed for projection years.
Average analysis	U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, , Commercial Fertilizers, Final Consumption for the Year, ended June 30th 1976.	National historical average analysis applied to the ORS hinterland.
Projected acreas harvested by BEA and BEA segment, by crop	Group V Report. Modified to account for hinterland differences between Group V and Group VI.	Projected acres harvested derived by dividing projected production by BEA and BEA segment, by yield per acre assumed in USDA, NIRAP Projections.

Source: Robert R. Nathan Associates, Inc.

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Table 9. Ohio River Basin: Consumption of Industrial and Agricultural Chemicals, by BEAs or BEA Segments,[a] Estimated Average 1974-76 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

BEA and BEA segment	Estimated average 1974-76	Projected					Average annual percentage change	
		1980	1990	2000	2020	2040	1974-76--2000	2000-2040
Primary Study Areas	13,921.5	16,140.5	22,250.3	30,725.2	52,342.8	69,231.6	3.2	2.1
BEA 47: Huntsville, AL	805.8	1,024.0	1,656.4	2,492.7	4,727.7	6,594.6	4.6	2.5
BEA 48: Chattanooga, TN	1,146.1	1,478.2	2,195.3	3,157.6	5,722.3	7,747.6	4.1	2.3
BEA 49: Nashville, TN	1,158.8	1,315.7	1,822.7	2,507.4	4,134.5	5,394.1	3.1	1.9
BEA 50: Knoxville, TN	927.0	1,114.9	1,561.0	2,170.3	3,793.2	5,045.2	3.5	2.1
BEA 52: Huntington, WV	1,422.5	1,689.6	2,045.1	2,604.2	4,062.0	5,092.3	2.4	1.7
BEA 54: Louisville, KY	1,219.5	1,446.1	2,053.1	2,882.4	5,046.9	6,725.5	3.5	2.1
BEA 55: Evansville, IN	926.5	676.3	979.4	1,339.6	2,146.5	2,744.2	1.5	1.8
BEA 62: Cincinnati, OH	1,893.0	2,286.8	3,297.9	4,638.5	8,230.3	11,031.4	3.6	2.2
BEA 64: Columbus, OH	957.4	1,310.3	1,786.9	2,577.9	4,734.7	6,497.0	4.0	2.3
BEA 66: Pittsburgh, PA	2,885.0	3,246.4	3,907.4	5,018.8	7,501.3	9,400.3	2.2	1.6
BEA 68: Cleveland, OH	37.4	38.6	49.0	60.6	91.2	114.5	1.9	1.6
BEA 115: Paducah, KY	542.5	613.1	896.1	1,275.2	2,152.2	2,844.9	3.5	2.0

Note: Industrial chemical consumption for the period 1980-2040 was estimated using the 1974-76 annual average of industrial chemical consumption, by BEA and BEA segment and consuming industry, and growth rates by BEA of these consuming industries (chemical and allied products, textile products, paper and allied products, petroleum refining products, primary metal products, and miscellaneous manufacturing products). Growth rates for the period 1980-2020 were obtained from OBERS Projections. Annual growth rates for the period 2020-2040 were assumed equal to half the annual growth rate projected for the period 2000-2020. Agricultural chemical consumption was derived by the multiplication of fertilizer application rates (in N, P_2O_5, and K_2O primary nutrient units) for corn, wheat and soybeans by the percent of harvested acres receiving fertilizer times a factor for acres planted and fertilized but not harvested by the tons of fertilizer material necessary to provide 1 ton of primary nutrient. Fertilizer material tons were derived by dividing the estimated domestic supply of N, P_2O_5 and K_2O chemical materials by the average analysis (i.e. the percentage of primary nutrient contained per unit of chemical material). Fertilizer material tons, application rates and percent of acres fertilized assumed constant after 1990.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: The 1974-76 annual average of consumption from Table 9. Average annual growth rates were derived from U.S. Water Resources Council, OBERS Projections, Regional Economic Activity in the U.S., Series E, 1972 ed. Nitrogenous, potassic and phosphatic chemical fertilizer material estimated future supply from Tennessee Valley Authority, Economics and Marketing Research Section: World Fertilizer Capacity, February 1979. Projected fertilizer application rates and percent of acres fertilized from Fertilizer Institute, Third World Fertilizer Conference Proceedings, "Musings on the U.S. Fertilizer Industry, 1990" (Remarks of Dr. John Douglas, Assistant to the Manager, Tenessee Valley Authority), September 1978. Projected acres harvested by BEA and BEA segment derived from Grains (Group V) Report.

During the period 2000-2040, the average annual increase in chemical consumption in the PSAs will be 2.1 percent (Table 9). As in the period 1974-76 to 2000, higher rates of growth are projected for industrial chemical consumption than for agricultural chemical consumption.

The fastest growth in consumption is projected to occur in BEAs 47 (Huntsville), 48 (Chattanooga) and 64 (Columbus). This will result from high levels of growth in the chemical, paper and allied products, petroleum refining, and miscellaneous manufacturing industries in BEA 47. High levels of growth will result in the chemical and textile industries in BEA 48 and in the chemical industry in BEA 64.

BEA 62 (Cincinnati) will replace BEA 66 (Pittsburgh) as the major consuming PSA by the year 2020. This will result from higher rates of growth in the chemical, primary metal product and miscellaneous manufacturing industries projected for BEA 62 relative to BEA 66.

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III. COMMODITY RESOURCE INVENTORY

Production of industrial and agricultural chemicals in the PSAs increased from 7.9 million tons in 1969 to 10.0 million tons in 1976, an average annual increase of 3.3 percent. Between 1974-76 and 2000, production in the PSAs is expected to increase at the slightly higher rate of 3.7 percent. During the 2000-2040 period, production in the PSAs will increase at the average annual rate of 2.2 percent.

A. Production Areas

The production of Group VI commodities in the PSAs is supplemented by production in Secondary Production Areas (SPAs) located outside the Ohio River Basin. These SPAs are defined as BEAs which are the origins of Group VI waterborne movements destined to the Ohio River Basin.

The major producing PSA was BEA 52 (Huntington). It was also the second largest shipper of Group VI products in the ORS hinterland. Other major producing PSAs were BEAs 62 (Cincinnati), 54 (Louisville), 64 (Columbus) and 66 (Pittsburgh).

Major SPAs were BEAs 138 (New Orleans) and 141 (Houston). Together, these BEAs accounted for 79 percent of the inbound commerce of Group VI. These BEAs shipped an assortment of industrial chemicals, ranging from alcohols to petrochemicals, to points throughout the ORS hinterland.

Other SPAs in the Gulf Coast area were BEAs 137 (Mobile), 140 (Beaumont), 143 (Corpus Christi) and 144 (McAllen). Together, these BEAs shipped 866.5 thousand tons (over 13 percent of total inbound ORS commerce of Group VI) to the ORS hinterland in 1976. Most of these shipments were basic chemicals, alcohols and petrochemicals.

Most of the remaining inbound shipments in 1976 were from BEAs 77 (Chicago) and 114 (St. Louis). Major shipments from BEA 77 were benzene and toluene which went to BEA 52. Almost half of BEA 114's shipments were sulfuric acid movements to primary metal producers in BEAs 115 (Paducah) and 49 (Nashville). Approximately 25 percent of BEA 114's shipments were basic chemicals movements to BEA 66 (Pittsburgh).

B. Production Characteristics

The chemical industry is one of the four largest industries in the United States. Twenty eight of the 500 largest industrial companies reported that over 25 percent of their sales were chemicals in 1968. Another 126 companies produced some amount of chemicals and allied products.[1] As firms have expanded operations to include products related to the companies' operations, these numbers have probably increased in the past decade. Most major oil companies produce petrochemicals, and metal producers often are involved in the production of sulfuric acid. The capital requirements of chemical production, however, are quite substantial. New entries to the industry are usually by established firms which, because of the desire to capitalize on in-house research and innovation or because of the incentives of vertical integration, will enter limited chemical production as a complement to existing operations.

B-1. Economic Characteristics

Although the U.S. level of exports has remained substantial and steady, foreign competition for export markets has become more pronounced over the past decade. A growing fear of the industry is that, as government regulation pushes the cost of production up, foreign producers will be able to obtain portions of the export market. These problems, however, will have only indirect bearing on PSA production since most consumption of that production is domestic.

The U.S. chemical industry is highly capital and energy intensive, input-oriented, integrated, and subject to short-term price, supply, and demand fluctuations.

The geographical concentration of production shifted during the late sixties from a scattered, market-oriented pattern to one

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1. Jules Backman, The Economics of the Chemical Industry, (Washington, D.C.: Manufacturing Chemists Association, 1970).

which was heavily based in the Southeast, Southern Plain and Delta states. Production has shifted away from areas of increasing consumption toward areas of greater relative availability of primary inputs, oil, natural gas, potash, and phosphate rock reserves. This is due to increases in the relative cost of transportation which have come to favor the transportation of lighter and less bulky finished products rather than primary inputs.

Gulf Coast production allows the industry adequate on-site storage facilities which are necessary for year-round production. In addition, through use of the interior and coastal waterways, these locations permit the industry greater latitude in serving both domestic and export markets.

The fertilizer industry is becoming more vertically integrated as economies-of-scale are gained from integrated on-site process lines and the sharing of off-site supporting facilities, storage, transportation, and marketing facilities.

> The availability of fertilizers to the agricultural sector depends on several forces not felt directly by farmers, but these forces do affect the structure of the industry -- the sizes and number of firms and plants, concentration of buyers and sellers, and conditions of entry. These elements bear directly on both the present and future supplies of materials and, consequently, on prices of fertilizer materials.[1]

Uncertainties in terms of feedstock costs and availability, government energy program and pollution abatement costs, penetration of the market by imports, and dramatic increases in capital and research and development costs have faced the industry on the supply side. Uncertainties regarding farmers' intended planting, fertilizer application rates and weather face the industry on the demand side. Rising costs associated with capital, energy, technology, and market penetration make new firm entry unlikely in the next decade.

The combination of uncertainties has slowed the speed of the fertilizer industry's adjustments to changes in domestic and worldwide demand and has resulted in a perennial mismatching of supply

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1. U.S. Department of Agriculture, Economic Research Service, The Changing U.S. Fertilizer Industry, Agricultural Economic Report No. 378, by Duane A. Paul et. al. (Washington, D.C.: USDA, 1977).

and demand. The historical industry ten-year market cycle has been drastically abbreviated, and erratic prices and profits have become more familiar.

B-2. Technological Characteristics

As stated earlier, research and development in the chemical industry has been a major factor contributing to the growth of the industry. Besides development of new products and new uses for existing products, advances in production methods are important results of the chemical industry's research and development efforts. New production techniques have contributed to cost reductions and price levels which have increased at a rate lower than that of the wholesale price index. An example of this has been the conversion of electrolytic caustic soda-chlorine plants to new dimensionally-stable anodes which increase efficiency and require less electric power.[1]

Innovations in chemical fertilizer manufacturing processes have been accompanied by reductions in unit costs. Important technological advances in the 1970s include changes in finished product form; reductions in equipment size, waste heat, power requirements, and synthesis pressure; and redesigns of generator systems. The single most important process innovation is the pipe reactor and pipe-cross reactor units. These eliminate the costly dryer system (and the fuel consumption associated with it) while producing high-analysis grades at lower overall pollution levels.

The Tennessee Valley Authority (TVA) has played an active role in the development, demonstration and dissemination of advances in fertilizer-technology. TVA has begun to address itself to the most pressing need for new technology: the creation of an economically viable alternative to natural gas as a chemical fertilizer feedstock. TVA's "Ammonia from Coal" projects are designed to develop and demonstrate coal gasification using a variety of both high- and low-sulfur coals to produce feedstocks for producing ammonia synthesis gas. It is expected, however, that major shifts from natural gas to coal feedstocks will not occur until the late 1990s.

In the short run, likely innovations in the fertilizer industry's production operations will be in the development of energy-saving processes, the development and application of economically acceptable pollution control methods, and the economic utilization of marginal phosphate ores.

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[1] U.S. Department of Commerce, Industry and Trade Administration, U.S. Industrial Outlook, 1979 ed. (Washington, D.C.: GPO, 1979).

B-3. Institutional Characteristics

As stated earlier, many of the largest industrial firms are producing some amount of chemical products. There are approximately 70,000 chemicals being marketed in the United States. They are sold by firms that include major pharmaceutical producers, oil companies, glass manufacturers, film manufacturers, and tire producers.

Privately owned corporations own much of the domestic fertilizer productive capacity. Among the largest corporations, sales of fertilizer products usually represent a relatively small percentage share of total firm sales. Chemical fertilizer producers and their parent corporations are involved in the production and distribution of such other products as petroleum refining and related industries, plastic products, natural gas and crude oil extraction, and chemical and allied products. The nitrogen industry is becoming increasingly vertically integrated with growing co-location of production facilities. Nearly all urea plants are located adjacent to ammonia plants. Over two-thirds of ammonium nitrate plants are located at the same site as an ammonia facility.

Cooperatives are playing an important role in the fertilizer industry and have increased their aggregate market share in the 1950-1970 period from 15 to over 30 percent. Cooperatives are involved in manufacturing, marketing and distributing chemical fertilizer through an extensive system of local facilities.

The chemical industry faces a multitude of environmental problems related to production operations and solid waste disposal. Problems include the control of noise, particulates emission, and fumes in the working area; protection of the worker from exposure to potential carcinogens; control of contaminants in effluent water; and control of fluorine, other fumes and particulates in stack emissions. The basic phosphate sector faces particular problems in the maintenance and control of slimes and tailings ponds, and the restoration of mined-out areas.

Of special interest to the chemical industry is the Toxic Substances Control Act of 1976, administered by an office of the Environmental Protection Agency.[1] This office has responsibility for determination of criteria to assess chemical substances, standards for testing procedures, and regulations for the control of hazardous substances. The Toxic Substances Control Act (TSCA) confers broad powers on EPA to regulate all manufacture, distribution and sale of chemical substances which may be found to be hazardous. A firm wishing to manufacture or distribute in commercial quantities of any chemical substance not already cleared by EPA must notify EPA prior to production. It must furnish sufficient information to enable an assessment of possible hazards associated with the manufacture, distribution, and intended usages of the substances. Attempts to assess the cost to industry of compliance with TSCA have yielded widely divergent estimates ranging from $80 to $140 million by EPA to $2 billion by a chemical industry member. A business consulting firm has set the monetary cost at between $360 million to $1.3 billion.[1] The same consulting firm concludes that the great burden of compliance with TSCA will fall on small companies which must allocate larger relative amounts of capital spending to comply with government regulations. Because of TSCA, smaller companies are expected to produce 75 to 90 percent fewer new products relative to 10 to 25 percent fewer new products for the larger companies.[2] According to the assessment of the consultant, there will be increased merger, acquistion and bankruptcy for many smaller chemical manufacturers. Companies are expected to grow by acquisition and merger rather than by internal innovation. A major concern to the industry, besides that of the cost of compliance, is one of confidentiality of "trade-secret" information relating to product development.

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[1] P.L. No. 94-469, 15 U.S. Code §2601, October 11, 1976.

Engineering solutions to pollution problems exist in the forms of dust control, condenser-type scrubbing equipment, and chemical neutralizers. However, in some sectors of the industry, particularly in the production of finished fertilizers, the financial burden of environmental control has led to the closing of some marginal operations.

The most serious long-term problem facing the chemical industry is the depletion of feedstocks and reserves. Rising costs impact on the industry in terms of process inputs, resource recovery, fuel use in manufacturing, and transport costs per ton mile. Natural gas and oil shortages are expected to be cyclical and short-lived in the next decade. At present, the industry accounts for about 3 percent of domestic natural gas and natural gas liquid consumption and for about 6.5 percent of petroleum and petroleum products demand.[1]

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[1] U.S. Department of Commerce, Industry and Trade Administration, U.S. Industrial Outlook, 1978 ed. (Washington, D.C.: GPO, 1978).

[2] Ibid.

As industries which are unable to convert to coal as an alternative fossil fuel are given priority in the use of natural gas (after residential consumers), the Energy Supply and Conservation Act of 1974 and the Energy Policy Act of 1976 will be more likely to impact on price in the short run than on supply. However, post-1980 is more uncertain and "economically viable" alternative feedstocks and fuel sources are, at present, unavailable. Known natural gas reserves may not last more than another 20 to 25 years.

U.S. reserves of phosphorous-bearing rock deposits of commercial grade are concentrated in central Florida, North Carolina and Idaho and represent an estimated 6 percent of global resources. The United States is, at present, responsible for about 38 percent of global production and 28 percent of consumption. Phosphate rock exports are sizable, and an estimated 30 percent of North Carolina and Florida rock is sold abroad. Metallurgical developments have permitted the economic utilization of low grade ores. The phosphate industry faces no significant resource problems in the coming 15 years.

Potash production in the United States has declined since 1965 and is expected to continue to decline. The percentage of potassic fertilizer consumption satisfied by imports has increased to a present level of over 75 percent. Canada satisfies the majority of this need and will strengthen its present major supplier role as U.S. potash production capacity is expected, by 1985, to drop 30 percent from a 1967 base of 4.02 million tons of K_2O.[2]

C. Existing Production Levels

Between 1969 and 1976, production of industrial and agricultural chemicals increased from 177.5 million tons to 213.3 million tons at an average annual increase of 3.9 percent. In the

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1. U.S. Department of Commerce, Industry and Trade Administration, U.S. Industrial Outlook, 1979 ed. (Washington, D.C.: GPO, 1979).
2. Tennessee Valley Authority, Economics and Marketing Research Section, World Fertilizer Capacity (computer printout: 7 Feb. 1979).

PSAs, production increased from 7,905.5 thousand tons in 1969 to 9,892.0 thousand tons in 1976, an average increase of 3.3 percent (Table 10).

The major chemical produced in the United States is sulfuric acid. Over 33.5 million tons of it were produced in 1976.[1] In the same year, production of sodium hydroxide exceeded 10.5 million tons; production of benzene and toluene totalled 8.8 million tons; production of agricultural chemicals was approximately 30 million tons; and other industrial chemicals contributed 130.4 million tons to domestic supply.

The major producing PSA was BEA 52 (Huntington), which contributed about 21 percent of total chemical production in the PSAs during the period 1969-76. Production in this BEA, however, declined during the last decade from 1,935.9 thousand tons in 1969 to 1,665.0 thousand tons in 1976. This decline reflects a national trend; a shift is being seen in chemical production from points of consumption to locations near sources of raw materials or less costly production inputs (such as labor).

Substantial growth did occur, however, in BEAs 50 (Knoxville) and 66 (Pittsburgh). The latter's growth is, to a certain extent, a reflection of the expansion of coal by-products as feedstocks for various organic chemicals. BEAs 47 (Huntsville), 55 (Evansville) and 115 (Paducah) are also estimated to have experienced relatively rapid rates of growth in the past decade.

D. Forecasting Procedures and Assumptions

State level data on industrial and agricultural chemical production in 1972 served as the basis for estimating production in the PSAs.[2] These data were distributed among counties using the distribution of chemical employees.[3] The only other source of county level chemical data provided capacity by plant which could be compared with national capacity and production information to provide BEA specific production data by chemical.[4] These data,

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[1] "Facts and Figures for the Chemical Industry," Chemical and Engineering News, 12 June 1978.

[2] U.S. Department of Commerce, Bureau of the Census, Census of Transportation, 1972 ed. (Washington, D.C.: GPO, 1976).

[3] U.S. Department of Commerce, Bureau of the Census, County Business Patterns, 1970-76 eds. (Washington, D.C.: GPO, 1972-79).

[4] Stanford Research Institute, Directory of Chemical Producers, 1978 (Menlo Park, CA: SRI, 1978).

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Table 10. Ohio River Basin: Production of Industrial and Agricultural Chemicals, by BEAs or BEA Segments,[a] Estimated 1969-76

(Thousands of tons unless otherwise specified)

BEA and BEA segment		1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Primary Study Areas		7,905.5	8,012.1	7,937.8	8,260.4	8,501.3	9,382.4	9.199.0	9,892.0	3.3
BEA 47:	Huntsville, AL	620.2	648.9	671.7	665.3	738.0	904.0	900.2	1,034.6	7.6
BEA 48:	Chattanooga, TN	429.6	401.2	408.8	411.7	419.7	437.9	411.5	450.5	0.7
BEA 49:	Nashville, TN	364.3	348.5	333.2	335.7	344.3	361.0	341.7	375.2	0.4
BEA 50:	Knoxville, TN	113.7	110.2	117.7	170.7	224.6	284.0	311.0	386.5	19.1
BEA 52:	Huntington, WV	1,935.9	1,963.2	1,876.3	1,894.7	1,717.0	1,810.6	1,673.4	1,665.0	(2.1)
BEA 54:	Louisville, KY	1,144.8	1,127.3	1,065.5	1,046.8	1,104.9	1,234.2	1,197.7	1,275.2	1.6
BEA 55:	Evansville, IN	176.6	187.1	192.5	212.6	245.1	325.3	297.8	318.9	8.8
BEA 62:	Cincinnati, OH	1,111.6	1,165.7	1,158.4	1,177.4	1,227.7	1,229.2	1,225.4	1,287.7	2.1
BEA 64:	Columbus, OH	871.2	892.7	940.2	1,031.5	1,046.5	1,157.3	1,169.6	1,259.1	5.4
BEA 66:	Pittsburgh, PA	780.8	806.2	820.8	939.1	1,008.2	1,144.6	1,141.4	1,230.1	6.7
BEA 68:	Cleveland, OH	11.3	11.2	11.2	12.5	13.7	14.2	15.1	16.3	5.4
BEA 115:	Paducah, KY	345.5	349.9	341.5	362.4	411.6	480.1	514.2	592.9	8.0

Note: Production totals for BEAs and BEA segments were derived from 1972 shipments of industrial chemicals, agricultural chemicals and miscellaneous chemicals (SIC 281, 287, 289) *1972 Census of Transportation*. Shipment data exclude those shipments moved by pipeline, parcel post shipments, and commodities moved by own power (motorized vehicles, aircraft, etc.), and local shipments (commodities shipped less than 25 miles from the plant). Total shipments of each state were distributed among BEAs and BEA segments according to the percentage distribution of industrial chemical, agricultural chemicals and miscellaneous chemical employment by county in 1972. After 1972, production in each BEA and BEA segment was estimated using changes in chemical employment by state. Production for 1969 and 1970 were estimated by using the rate of change in earnings in chemical and allied products industry, *1972 OBERS Projections*.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Shipments from U.S. Department of Commerce, Bureau of the Census, *Census of Transportation*, 1972 ed. County and state employment data from U.S. Department of Commerce, Bureau of the Census, *County Business Patterns*, 1970-76 eds. Earnings from U.S. Water Resources Council, *OBERS Projections, Regional Economic Activity in the U.S.*, Series E, 1972 ed., Volume II.

however, are incomplete and do not provide capacity data for all chemicals. For the purpose of estimating future production and commodity flows of chemicals, use of the accessible state production information and county level employment data are satisfactory.

Several short-term projections of chemical production are available.[1] However, most of these do not provide projections beyond the early 1980s and are not BEA specific.

BEA level projections of earnings (in constant dollars) in the chemical industry to the year 2020 were developed by the U.S. Department of Commerce for the OBERS Projections published by the U.S. Water Resources Council.[2] Growth rates by BEA for the chemical industry were derived from these projections and were applied to appropriate BEAs and BEA segments. This procedure assumed that the ratio of the value of production as measured by earnings (in constant dollars) to production tonnage would remain constant in the Ohio River System hinterland. None of the industrial sources contacted during the course of this study were able to provide a method of quantifying potential shifts.

Growth rates for earnings in each PSA were assumed to be equal to the growth rate in the appropriate BEA. No projections of industrial activity beyond the year 2020 were identified. Therefore, a decrease in the rate of change experienced in the period

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[1] Review of projections of domestic chemical production indicate a lack of long-term projections with the exception of the OBERS Projections (Series E). The Department of Commerce provides annual five-year forecasts in the Industrial Outlook. The Energy Consumption in Manufacturing study (Cambridge, 1974) prepared for the Energy Policy Project of the Ford Foundation provides projections through 1980. The latter two sources project annual chemical production growth rates similar to those of the OBERS series. The National Planning Association does prepare state and metropolitan projections in its Regional Economic Projections Series. However, industry specific projections were made for employment, and would capture less of productivity changes than would earnings projections. Also, projections were made only through the year 1990. In a preliminary study (Tulsa Report) prepared for the Corps of Engineers, a 2.8 percent growth rate for the next few years for the chemical industry as a unit was cited.

[2] U.S. Water Resources Council, OBERS Projections, Regional Economic Activity in the United States, Series E, 1972 ed. (Washington, D.C.: GPO, 1974).

2000-2040 was assumed. This was based on the assumption that constraints to growth become more pronounced as growth occurs. Growth rates, by industry, for the period 2020-2040, were assumed to be equal to half the rates projected for the period 2000-2020.

E. Future Production Levels

Production of industrial and agricultural chemicals in the PSA was estimated to increase at the annual rate of 3.7 percent between 1974-76 and 2000. Production between the years 2000 and 2040 will continue to increase but at a lower rate of 2.2 percent (Table 11).

BEA 47 (Huntsville) was projected to increase production at the most rapid rate during the projection period. By the year 2020, BEA 47 will be the major producing PSA in the ORS hinterland.

BEA 52 (Huntington) will continue to be a major production center for chemicals in the region. However, its predominance will diminish. Other major BEAs will be BEAs 62 (Cincinnati), 64 (Columbus), 54 (Louisville) and 66 (Pittsburgh). These have been major chemical production areas in the past.

BEST DOCUMENT AVAILABLE

Table 11. Ohio River Basin: Production of Industrial and Agricultural Chemicals, by BEAs or BEA Segments,[a] Estimated Average 1974-76 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

BEA and BEA segment		Estimated average 1974-76	Projected					Average annual percentage change	
			1980	1990	2000	2020	2040	1974-76--2000	2000-2040
Primary Study Areas		9,491.1	11,964.9	16,974.5	24,068.3	43,390.8	58,506.7	3.7	2.2
BEA 47:	Huntsville, AL	946.3	1,280.8	2,142.5	3,330.5	6,717.2	9,568.9	5.2	2.7
BEA 48:	Chattanooga, TN	433.3	583.7	881.6	1,291.3	2,415.0	3,310.8	4.5	2.4
BEA 49:	Nashville, TN	359.3	425.9	546.3	727.7	1,208.9	1,560.6	2.9	1.9
BEA 50:	Knoxville, TN	327.2	403.9	584.2	834.4	1,512.9	2,041.7	3.8	2.3
BEA 52:	Huntington, WV	1,716.3	2,068.1	2,508.7	3,233.4	5,145.3	6,499.4	2.6	1.8
BEA 54:	Louisville, KY	1,235.7	1,551.7	2,182.5	3,063.8	5,437.7	7,259.1	3.7	2.2
BEA 55:	Evansville, IN	314.0	382.4	515.4	704.9	1,215.0	1,598.2	3.3	2.1
BEA 62:	Cincinnati, OH	1,247.4	1,597.3	2,382.7	3,466.4	6,433.2	8,784.9	4.2	2.4
BEA 64:	Columbus, OH	1,195.3	1,535.7	2,286.4	3,323.1	6,155.3	8,397.1	4.2	2.3
BEA 66:	Pittsburgh, PA	1,172.0	1,454.9	1,984.0	2,739.7	4,750.3	6,266.9	2.5	2.1
BEA 68:	Cleveland, OH	15.2	18.6	24.7	33.5	56.9	74.3	3.2	2.0
BEA 115:	Paducah, KY	529.1	661.9	935.5	1,319.6	2,351.1	3,144.8	3.7	2.2

Note: The 1974-76 three years average of estimated production of industrial chemicals, agricultural chemicals and miscellaneous chemicals (SIC 281, 287, 289) were projected for 1980-2020 using the growth rates of earnings in the chemical and allied products industry as projected by U.S. Department of Commerce, OBERS Projections. Production by BEA and BEA segment was assumed to increase between 2020 and 2040 at rates equal to half the growth rates projected for the period 2000-2020.

[a] BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Average production for 1974-76 from Table 10. Average annual growth rates were derived from U.S. Water Resources Council, OBERS Projections, Regional Economic Activity in the U.S., Series E, 1972 ed., Vol. II.

IV. TRANSPORTATION CHARACTERISTICS

At the national level, water is a major mode of transport for industrial and agricultural chemicals. Of the 127.2 million tons of industrial and agricultural chemicals shipped in 1972,[1] 16 percent were shipped by water, 45 percent by rail, and the remainder by truck or other means.[2] Within the ORS hinterland, net water shipments (outbound less inbound) are substantial enough to cover the difference between the PSAs' consumption and production.

A. Existing and Historical Modal Split

In 1976, the PSAs were net receivers of industrial and agricultural chemicals. While inbound and outbound shipments by rail and by truck balanced such that net shipments for both modes were under 1 million tons, inbound water receipts exceeded outbound shipments by over 5.5 million tons (Table 12).

Gross rail shipments for the PSAs totalled 11,809.5 thousand tons in 1976, compared to 11,364.0 thousand tons by water. Major shipping areas for rail to the PSAs were the Gulf Coast and the Great Lakes. Major receivers of chemical rail shipments from the PSAs were the Carolinas, the Great Lakes, Virginia and the Middle Atlantic states.

These shipments were comprised mostly of basic chemicals, sulfuric acid, sodium hydroxide and agricultural chemicals. Relatively more agricultural chemicals are moved by rail than by water in the ORS hinterland, and; more basic chemicals are moved by water than by rail.

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1. As defined to include SIC codes 281 (Industrial chemicals), 287 (Agricultural chemicals) and 289 (Miscellaneous chemicals).
2. U.S. Department of Commerce, Bureau of the Census, Census of Transportation, 1972 ed. (Washington, D.C.: GPO, 1976).

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Table 12. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Industrial and Agricultural Chemicals, by BEAs or BEA Segments,[a] Estimated 1976

(Thousands of tons)

BEA and BEA segment	Production	Consumption	Shipments (receipts)									
			Total net	Water[b]				Rail[c]				Net truck
				Net	Inbound	Outbound	Local	Net	Inbound	Outbound	Local	
Primary Study Areas	9,892.0	15,263.2	(5,371.2)	(5,459.2)	6,353.8[d]	894.6[d]	4,115.6[d]	601.0	4,866.8[d]	5,467.8[d]	1,474.9[d]	(513.0)
BEA 47: Huntsville, AL	1,034.6	914.3	120.3	(878.0)	1,107.8	229.8	25.6	558.9	516.4	1,075.3	33.8	439.4
BEA 48: Chattanooga, TN	450.5	1,245.5	(795.0)	(213.7)	253.6	39.9	-	534.3	788.5	1,322.8	15.0	(1115.6)
BEA 49: Nashville, TN	375.2	1,290.0	(914.8)	(457.6)	489.0	31.4	-	(85.6)	489.4	403.8	31.5	(371.6)
BEA 50: Knoxville, TN	386.5	1,105.3	(718.8)	(15.6)	15.6	-	-	(146.0)	150.8	4.8	--	(557.2)
BEA 52: Huntington, WV	1,665.0	1,455.1	209.9	(2,989.9)	3,585.2	595.3	551.0	536.8	610.8	1,147.6	110.0	2,663.0
BEA 54: Louisville, KY	1,275.2	1,330.5	(55.3)	(262.7)	290.8	28.1	-	(371.8)	872.3	500.5	--	579.2
BEA 55: Evansville, IN	318.9	1,064.3	(745.4)	(701.1)	759.1	58.0	5.2	(379.3)	490.0	110.7	--	335.0
BEA 62: Cincinnati, OH	1,287.7	2,036.2	(748.5)	(1,232.8)	1,277.4	44.6	21.1	(233.9)	760.8	526.9	14.9	718.2
BEA 64: Columbus, OH	1,259.1	1,048.8	210.3	1,626.9	204.1	1,831.0	-	(78.6)	257.4	178.8	--	(1,338.0)
BEA 66: Pittsburgh, PA	1,230.1	3,085.6	(1,855.5)	(374.4)	1,124.5	750.1	330.3	337.1	640.1	977.2	80.5	(1,818.[illegible])
BEA 68: Cleveland, OH	16.3	40.9	(24.6)	41.3	18.8	60.1	-	(0.1)	10.1	10.0	--	(65.8)
BEA 115: Paducah, KY	592.9	646.7	(53.8)	(1.6)	357.3	355.7	53.0	(70.8)	300.5	229.7	20.1	18.6

Note: Gross and net waterborne and net rail shipments(receipts) were determined for 1976 from U.S. Army Corps of Engineers waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting consumption from production. Net truck shipments (receipts) were determined by subtracting net waterborne and rail shipments (receipts) from total net shipments (receipts).

a. BEA segments are defined as counties which are ultimate origins or destinations of waterborne movements.

b. Includes 31.2 thousands tons of synthetic rubber and gum and wood chemicals.

c. Rail movements of industrial and agricultural chemicals were estimated from rail movements of all chemical products using 1972 ratio of industrial and agricultural chemical rail shipments to total chemical and rail shipments to, from, and within the Primary Study Areas.

d. Total Primary Study Area shipments equal inbound, outbound, and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Production and consumption from Tables 7 and 10. Water and rail shipments from Waterborne Commerce by Port Equivalents, 1969-76, and ICC Railroad Waybill Sample, 1972 and 1976, supplied by the U.S. Army Corps of Engineers.

BEAs 47 (Huntsville), 52 (Huntington), 55 (Evansville), 62 (Cincinnati) and 66 (Pittsburgh) are major users of the waterway. They reported substantial amounts of waterborne chemical receipts in 1976 (Table 12). BEA 66, however, relies on truck transport as a means of supplying the gap between production and consumption. This is also true for BEA 48 (Chattanooga). BEA 47 reported large quantities of outbound chemicals by rail, as did BEAs 48, 52 and 66. The major phenomenon occurring with these movements is that PSAs may ship as many Group VI products as they receive. This results because chemicals are used as inputs for the production of other chemicals. So, in the PSAs, many chemical inputs will be shipped from an area such as the Gulf Coast, processed and then consumed within the ORS hinterland or in the surrounding regions.

B. Intermodal Characteristics

Most shippers and receivers of Group VI products are located at waterside or have rail facilities at the plant site. There are very few intermodal transfers. The existing rate structures discourage barge to rail or rail to barge shipments. Highway transportation is the major link in intermodal movements. Containerization continues to expand and to boost the efficiency of rail to truck transfers. With respect to barge-truck transshipment, although the use of containers on ocean-going vessels has grown, containerization is not now a factor on the inland waterway.

C. Factors Affecting Modal Choice

The modes of transportation differ for the movements of many chemicals. The physical characteristics of some chemicals and the locations of available points of supply limit movements to certain modes. For instance, the primary sources of potash are mines in Canada and the western United States, and most potash is shipped east via rail. Ammonium nitrate is a highly explosive material which is prohibited from shipment on the inland waterways.

The Primary Study Areas are primarily consumers of basic chemicals which form the building blocks for more specialized chemicals. Although some of these basic chemicals are produced in the ORS hinterland, the region must rely on supplies from elsewhere, specifically the Gulf Coast. When a consuming firm has access to water transportation and scheduling permits, barge is the preferred mode of transport. This is because, of the major modes of transport, barge is the least expensive. Its use, however, is limited to the waterway system, and delivery schedules are subject to a degree of variability due to weather and traffic delays.

D. Forecasting Procedures and Assumptions

Projections of modal split were based on the 1976 relationships between production and consumption and gross outbound and inbound water and rail movements by BEA, except when data, analyses and conversation with chemical shippers indicated otherwise. Gross inbound waterborne and rail receipts for each PSA were estimated as a proportion of consumption. Gross outbound waterborne and rail shipments for each PSA were estimated as a proportion of production. Several plants were identified that have closed operations but had used the waterways in the period 1969-76. Adjustments for these shipments were made based on dock reports and conversations with personnel at these plants.

E. Probable Future Modal Split

Production of chemicals in the PSAs is projected to increase faster than consumption (Table 13). However, inbound water shipments will continue to exceed outbound shipments during the entire projection period. Net rail shipments will increase from 601.0 thousand tons in 1976 to 12,426.2 thousand tons in 2040. Net truck shipments will increase from 513.0 thousand tons in 1976 to 7,120.7 thousand tons in 2040.

F. Probable Future Waterways Traffic Flows

Gross waterborne shipments are projected to increase from 11.4 million tons in 1976 to 22.4 million tons by 2000, at an average annual increase of 2.7 percent. From 2000 to 2040, the average annual increase is projected to be 2.3 percent.

BEA-to-BEA waterborne traffic projections are presented in Table 14. Growth indices derived from the traffic projections are presented in Table 15.

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Table 13. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Chemicals and Chemical Fertilizers,[a] Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

	Estimated 1976	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1976-2000	2000-40
Production	9,892.0	11,964.9	16,974.5	24,068.3	43,398.8	58,506.7	3.8	2.3
Consumption	15,263.2	16,140.5	22,250.3	30,725.2	52,342.8	69,231.6	3.0	2.1
Net shipments (receipts)	(5,371.2)	(4,175.6)	(5,275.8)	(6,656.9)	(8,944.0)	(10,724.9)	0.9	1.2
Net waterborne	(5,459.2)	(5,266.1)	(6,607.3)	(8,492.7)	(12,793.3)	(16,030.4)	1.9	1.6
Net rail	601.0	1,751.0	2,692.6	4,150.1	8,754.8	12,426.2	8.4	2.8
Net truck	(513.0)	(660.5)	(1,361.1)	(2,314.3)	(4,905.5)	(7,120.7)	6.5	2.9
Gross waterborne shipments:								
Outbound	894.6	1,074.9	1,471.5	2,047.6	3,613.4	4,822.4	3.5	2.2
Inbound	6,353.8	6,341.0	8,078.8	10,540.3	16,406.7	20,852.8	2.1	1.7
Local	4,115.6	4,980.1	6,983.4	9,831.7	17,544.7	23,520.1	3.7	2.2
Total	11,364.0	12,396.0	16,533.7	22,419.6	37,564.8	49,195.3	2.9	2.0

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for the ORS hinterland was estimated from projections of modal split for each BEA and BEA segment. Projected modal split remains constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments (inbound, outbound, local) were projected by assuming that the relationship between gross inbound shipments and consumption and gross outbound shipments and production in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise.

a. Includes only industrial and agricultural chemicals.

Source: Tables 9, 11 and 12; Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

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Table 14. Ohio River System: BEA-to-BEA Waterborne Traffic of Chemicals and Chemical Fertilizers, Actual 1976 and Projected 1980-2040, Selected Years

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS					
			1976	1980	1990	2000	2020	2040
038	052	06	67	74	82	99	140	168
039	066	06	11	11	12	15	20	24
045	052	06	150	166	184	221	314	377
046	054	06	56	58	82	115	200	266
046	055	06	45	28	42	57	93	119
046	062	06	211	225	286	370	573	722
047	046	06	100	125	212	329	663	943
047	047	06	256	347	650	1037	2122	2960
047	048	06	11	17	31	56	101	137
047	049	06	11	13	23	35	71	98
047	052	06	550	658	827	1142	2572	3934
047	055	06	119	104	205	335	698	1000
047	062	06	227	315	625	1080	1916	2568
047	066	06	102	125	204	314	594	835
047	077	06	444	550	988	1528	3070	4345
047	078	06	33	40	69	107	216	307
047	079	06	33	41	69	107	216	307
047	089	06	111	136	228	355	717	1021
047	091	06	45	56	93	145	292	416
047	107	06	22	27	46	71	143	203
047	108	06	56	69	116	180	364	518
047	113	06	78	97	162	251	507	722
047	114	06	45	57	95	147	298	424
047	141	06	289	358	600	932	1881	2681
047	915	06	22	27	47	72	144	207
048	049	06	45	62	104	163	299	405
048	077	06	44	57	87	127	237	324
048	078	06	134	172	243	354	665	914
048	079	06	100	130	196	287	538	737
048	081	06	56	71	106	156	289	397
048	115	06	20	25	45	57	112	156
049	052	06	264	296	367	484	800	1031
049	055	06	50	60	90	125	212	275
052	039	06	21	26	32	41	65	82
052	046	06	301	371	449	578	921	1162
052	047	06	487	694	1122	2048	4565	6368
052	049	06	457	586	772	1096	1854	2399
052	052	06	5510	6766	7753	9246	13180	15924
052	054	06	160	203	263	354	619	791
052	055	06	90	79	121	162	254	315
052	062	06	295	394	582	841	1561	2114
052	066	06	1029	1258	1452	1791	2655	3275
052	068	06	10	12	16	19	30	43
052	077	06	1400	1736	2103	2712	4316	5457
052	078	06	56	70	85	111	177	224

(Continued)

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Table 14. (Continued)

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS					
			1976	1980	1990	2000	2020	2040
052	081	06	100	126	154	199	320	405
052	089	06	10	14	17	22	35	45
052	114	06	132	164	206	265	424	534
052	115	06	70	81	121	170	298	367
052	137	06	50	62	75	97	155	195
052	138	06	410	509	621	801	1275	1611
052	139	06	30	37	45	58	93	117
052	140	06	95	117	141	181	286	360
052	141	06	720	895	1090	1406	2237	2825
052	143	06	30	37	51	66	105	133
054	052	06	70	86	93	103	156	188
054	078	06	78	93	130	183	325	434
054	114	06	11	13	18	25	44	59
054	115	06	100	123	203	313	583	798
054	138	06	11	13	18	25	44	59
054	141	06	11	13	18	25	44	59
055	054	06	30	37	55	79	148	200
055	055	06	52	44	69	98	174	230
055	062	06	140	187	239	320	542	706
055	066	06	10	12	15	20	31	40
055	077	06	60	72	97	132	226	298
055	078	06	30	35	47	64	111	146
055	079	06	140	167	225	308	530	698
055	138	06	70	84	113	155	267	352
055	143	06	20	24	33	44	74	97
055	144	06	80	96	129	177	305	401
062	049	06	11	14	23	35	71	102
062	052	06	363	445	580	762	1181	1649
062	055	06	20	18	32	48	91	126
062	062	06	211	274	484	783	1678	2249
062	066	06	10	12	17	24	43	57
062	078	06	22	27	40	58	108	148
062	140	06	20	25	39	58	109	149
064	047	06	0	0	1823	3743	14064	24689
064	052	06	18020	21876	30616	43320	73161	94046
064	054	06	130	159	253	410	782	1142
064	062	06	160	304	555	847	1503	2231
066	046	06	141	166	226	314	542	716
066	047	06	105	141	420	652	1237	2008
066	049	06	22	27	38	51	89	113
066	052	06	4943	5773	7014	9115	16025	20143
066	054	06	111	131	189	281	547	744
066	062	06	851	1059	1866	2885	5935	8555
066	064	06	291	400	620	951	1972	2822
066	066	06	3303	3845	5344	7425	11197	14447

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Table 14. (Continued)

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS					
			1976	1980	1990	2000	2020	2040
066	077	06	43	51	70	96	167	220
066	078	06	60	76	120	168	292	385
066	114	06	101	120	156	216	374	493
066	115	06	50	61	116	185	351	451
066	138	06	250	296	401	553	960	1266
066	140	06	22	27	36	49	84	111
066	141	06	155	183	244	338	585	772
066	143	06	345	408	550	761	1322	1745
066	915	06	11	13	16	23	41	53
068	052	06	400	458	619	846	1473	1939
068	066	06	190	215	275	366	587	751
068	135	06	11	13	17	23	38	50
077	047	06	50	53	79	162	367	530
077	052	06	711	787	873	996	1307	1507
077	062	06	33	33	45	61	103	134
077	066	06	45	47	51	62	84	100
079	052	06	11	12	14	16	29	28
091	047	06	200	213	317	449	774	1035
107	054	06	22	23	33	47	83	110
107	062	06	67	71	91	118	182	230
108	054	06	67	69	90	119	190	243
113	055	06	89	54	72	92	134	165
114	049	06	470	457	580	753	1164	1470
114	054	06	11	11	15	19	29	39
114	055	06	360	220	289	385	583	731
114	062	06	111	119	153	208	328	411
114	066	06	484	483	520	627	798	927
114	115	06	350	316	443	575	889	1134
115	046	06	690	773	1090	1535	2734	3657
115	047	06	190	233	282	424	497	510
115	048	06	20	30	51	61	126	183
115	049	06	270	307	460	554	1002	1362
115	054	06	410	465	714	1020	1845	2419
115	062	06	350	394	543	757	1418	1949
115	066	06	30	31	35	43	70	82
115	077	06	1220	1364	1861	2623	4662	6242
115	111	06	50	56	79	111	198	265
115	114	06	240	267	378	533	954	1272
115	115	06	530	545	818	1241	2355	3275
115	119	06	20	22	32	45	79	106
115	133	06	67	75	106	149	266	355
134	062	06	140	150	198	262	424	544
135	047	06	78	86	132	182	308	408
135	052	06	89	96	101	124	180	219
137	047	06	856	914	1001	1201	1645	1959
137	048	06	167	189	301	436	793	1089
137	049	06	523	509	765	1064	1778	2353
137	055	06	1479	893	1378	1930	3155	4078

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Table 14. (Continued)

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS					
			1976	1980	1990	2000	2020	2040
137	062	06	67	71	96	130	208	264
138	047	06	365	399	627	529	446	376
138	048	06	2226	2642	3891	5576	10044	13556
138	049	06	2848	2785	3828	5272	8553	11070
138	052	06	3266	3227	1901	1270	699	385
138	054	06	733	770	1054	1425	2374	3126
138	055	06	4778	3015	4219	5691	8925	11281
138	062	06	5896	6397	8856	11692	17169	20553
138	064	06	1302	1452	2109	2982	5218	7048
138	066	06	5124	5088	5667	6835	9392	11442
138	068	06	78	70	98	119	174	247
138	115	06	1930	1774	2470	3443	5529	7158
140	047	06	234	256	855	1853	2758	3754
140	049	06	11	12	16	19	29	35
140	052	06	1961	2147	1875	1412	928	610
140	054	06	11	12	16	19	29	35
140	055	06	50	31	40	51	74	91
140	062	06	712	774	1053	1470	2558	3421
140	066	06	970	973	1073	1310	2681	3245
141	047	06	8263	9073	12733	17955	28714	35721
141	048	06	101	118	176	270	535	734
141	049	06	189	184	258	409	675	928
141	050	06	156	157	220	306	535	711
141	052	06	4067	4173	4254	3738	1850	915
141	054	06	1134	1190	1678	2351	4088	5459
141	062	06	2928	3183	4559	6685	14628	21395
141	064	06	426	479	715	1040	1940	2661
141	066	06	3154	3122	3655	4715	7043	8891
141	068	06	100	95	111	141	215	236
141	115	06	1013	928	1412	2029	3413	4550
143	047	06	190	217	393	525	840	1068
143	048	06	11	13	19	29	53	74
143	049	06	22	21	28	37	61	78
143	052	06	660	709	665	757	970	1100
143	055	06	11	7	9	13	19	24
143	062	06	270	294	427	604	1070	1444
143	064	06	22	24	33	45	83	112
143	066	06	22	22	26	32	48	59
143	115	06	10	10	15	21	34	45
144	047	06	60	66	95	143	264	361
144	049	06	11	11	14	18	29	37
144	052	06	260	284	317	370	501	587
144	054	06	11	12	15	20	32	42
144	066	06	64	65	73	89	124	150
915	054	06	22	22	31	42	67	86

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Table 14. (Continued)

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
915	055	06	500	303	465	633	1001	1270
915	062	06	316	339	377	466	689	857
915	115	06	30	27	42	57	91	116
		TOTAL	113640	123960	165337	224196	375648	491953

Note: BEA 915 refers to counties of BEA 115 which are origins and destinations of waterborne movements shipped from and to points on the Mississippi River.

Source: Robert R. Nathan Associates, Inc.

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Table 15. Ohio River System: Growth Rates of Chemicals and Chemical Fertilizers Waterborne Commerce, BEA to BEA, Projected 1976-2040, Selected Years

BEA Pair[a]	Group No.	Index Value[b]	Year[c]					
			1976	1980	1990	2000	2020	2040
038052	06	67	1000	1104	1224	1478	2090	2507
039066	06	11	1000	1000	1091	1364	1818	2182
045052	06	150	1000	1107	1227	1473	2093	2513
046054	06	56	1000	1036	1464	2054	3571	4750
046055	06	45	1000	622	933	1267	2067	2644
046062	06	211	1000	1066	1355	1754	2716	3422
047046	06	100	1000	1250	2120	3290	6630	9430
047047	06	256	1000	1355	2539	4051	8289	11563
047048	06	11	1000	1545	2818	5091	9182	12455
047049	06	11	1000	1182	2091	3182	6455	8909
047052	06	550	1000	1196	1504	2076	4676	7153
047055	06	119	1000	874	1723	2815	5866	8403
047062	06	227	1000	1388	2753	4758	8441	11313
047066	06	102	1000	1225	2000	3078	5824	8186
047077	06	444	1000	1239	2225	3441	6914	9786
047078	06	33	1000	1212	2091	3242	6545	9303
047079	06	33	1000	1242	2091	3242	6545	9303
047089	06	111	1000	1225	2054	3198	6459	9198
047091	06	45	1000	1244	2067	3222	6489	9244
047107	06	22	1000	1227	2091	3227	6500	9227
047108	06	56	1000	1232	2071	3214	6500	9250
047113	06	78	1000	1244	2077	3218	6500	9256
047114	06	45	1000	1267	2111	3267	6622	9422
047141	06	289	1000	1239	2076	3225	6509	9277
047915[d]	06	22	1000	1227	2136	3273	6545	9409
048049	06	45	1000	1378	2311	3622	6644	9000
048077	06	44	1000	1295	1977	2886	5386	7364
048078	06	134	1000	1284	1813	2642	4963	6821
048079	06	100	1000	1300	1960	2870	5380	7370
048081	06	56	1000	1268	1893	2786	5161	7089
048115	06	20	1000	1250	2250	2850	5600	7800
049052	06	264	1000	1121	1390	1833	3030	3905
049055	06	50	1000	1200	1800	2500	4240	5500
052039	06	21	1000	1238	1524	1952	3095	3905
052046	06	301	1000	1233	1492	1920	3060	3860
052047	06	487	1000	1425	2304	4205	9374	13076
052049	06	457	1000	1232	1689	2398	4057	5249
052052	06	5510	1000	1228	1407	1678	2392	2890
052054	06	160	1000	1269	1644	2213	3869	4944
052055	06	90	1000	878	1344	1800	2822	3500
052062	06	295	1000	1336	1973	2851	5292	7166
052066	06	1029	1000	1223	1411	1741	2580	3183
052068	06	10	1000	1200	1600	1900	3000	4300
052077	06	1400	1000	1240	1502	1937	3083	3898

(Continued)

BEST DOCUMENT AVAILABLE

Table 15. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c]					
			1976	1980	1990	2000	2020	2040
052078	06	56	1000	1250	1518	1982	3161	4000
052081	06	100	1000	1260	1540	1990	3200	4050
052089	06	10	1000	1400	1700	2200	3500	4500
052114	06	132	1000	1242	1561	2008	3212	4045
052115	06	70	1000	1157	1729	2429	4257	5243
052137	06	50	1000	1240	1500	1940	3100	3900
052138	06	410	1000	1241	1515	1954	3110	3929
052139	06	30	1000	1233	1500	1933	3100	3900
052140	06	95	1000	1232	1484	1905	3011	3789
052141	06	720	1000	1243	1514	1953	3107	3924
052143	06	30	1000	1233	1700	2200	3500	4433
054052	06	70	1000	1229	1329	1471	2229	2686
054079	06	78	1000	1192	1667	2346	4167	5564
054114	06	11	1000	1182	1636	2273	4000	5364
054115	06	100	1000	1230	2030	3130	5830	7980
054138	06	11	1000	1182	1636	2273	4000	5364
054141	06	11	1000	1182	1636	2273	4000	5364
055054	06	30	1000	1233	1833	2633	4933	6667
055055	06	52	1000	846	1327	1885	3346	4423
055062	06	140	1000	1336	1707	2286	3871	5043
055066	06	10	1000	1200	1500	2000	3100	4000
055077	06	60	1000	1200	1617	2200	3767	4967
055078	06	30	1000	1167	1567	2133	3700	4867
055079	06	140	1000	1193	1607	2200	3786	4986
055138	06	70	1000	1200	1614	2214	3814	5029
055143	06	20	1000	1200	1650	2200	3700	4850
055144	06	80	1000	1200	1613	2213	3813	5013
062049	06	11	1000	1273	2091	3132	6455	9273
062052	06	363	1000	1226	1598	2099	3253	4543
062055	06	20	1000	900	1600	2400	4550	6300
062062	06	211	1000	1299	2294	3711	7953	10659
062066	06	10	1000	1200	1700	2400	4300	5700
062078	06	22	1000	1227	1818	2636	4909	6727
062140	06	20	1000	1250	1950	2900	5450	7450
064047	06	1823	0	0	1000	2053	7715	13543
064052	06	18020	1000	1214	1699	2404	4060	5219
064054	06	130	1000	1223	1946	3154	6015	8785
064062	06	160	1000	1900	3469	5294	9394	13944
066046	06	141	1000	1177	1603	2227	3844	5078
066047	06	105	1000	1343	4000	6210	11781	19124
066049	06	22	1000	1227	1727	2318	4045	5136
066052	06	4943	1000	1168	1419	1844	3242	4075
066054	06	111	1000	1180	1703	2532	4928	6703
066062	06	851	1000	1244	2193	3390	6974	10053
066064	06	291	1000	1375	2131	3268	6777	9698
066066	06	3303	1000	1164	1618	2248	3390	4374

(Continued)

BEST DOCUMENT AVAILABLE

Table 15. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c]					
			1976	1980	1990	2000	2020	2040
066077	06	43	1000	1186	1628	2233	3884	5116
066078	06	60	1000	1267	2000	2800	4867	6417
066114	06	101	1000	1188	1545	2139	3703	4881
066115	06	50	1000	1220	2320	3700	7020	9020
066138	06	250	1000	1184	1604	2212	3840	5064
066140	06	22	1000	1227	1636	2227	3818	5045
066141	06	155	1000	1181	1574	2181	3774	4981
066143	06	345	1000	1183	1594	2206	3832	5058
066915[d]	06	11	1000	1182	1455	2091	3727	4818
068052	06	400	1000	1145	1548	2115	3683	4848
068066	06	190	1000	1132	1447	1926	3089	3953
068135	06	11	1000	1182	1545	2091	3455	4545
077047	06	50	1000	1060	1580	3240	7340	10600
077052	06	711	1000	1107	1228	1401	1838	2120
077062	06	33	1000	1000	1364	1848	3121	4061
077066	06	45	1000	1044	1133	1378	1867	2222
079052	06	11	1000	1091	1273	1455	2636	2545
091047	06	200	1000	1065	1585	2245	3870	5175
107054	06	22	1000	1045	1500	2136	3773	5000
107062	06	67	1000	1060	1358	1761	2716	3433
108054	06	67	1000	1030	1343	1776	2836	3627
113055	06	89	1000	607	809	1034	1506	1854
114049	06	470	1000	972	1234	1602	2477	3128
114054	06	11	1000	1000	1364	1727	2636	3545
114055	06	360	1000	611	803	1069	1619	2031
114062	06	111	1000	1072	1378	1874	2955	3703
114066	06	484	1000	998	1074	1295	1649	1915
114115	06	350	1000	903	1266	1643	2540	3240
115046	06	690	1000	1120	1580	2225	3962	5300
115047	06	190	1000	1226	1484	2232	2616	2684
115048	06	20	1000	1500	2550	3050	6300	9150
115049	06	270	1000	1137	1704	2052	3711	5044
115054	06	410	1000	1134	1741	2488	4500	5900
115062	06	350	1000	1126	1551	2163	4051	5569
115066	06	30	1000	1033	1167	1433	2333	2733
115077	06	1220	1000	1118	1525	2150	3821	5116
115111	06	50	1000	1120	1530	2220	3960	5300
115114	06	240	1000	1113	1575	2221	3975	5300
115115	06	530	1000	1028	1543	2342	4443	6179
115119	06	20	1000	1100	1600	2250	3950	5300
115133	06	67	1000	1119	1582	2224	3970	5299
134062	06	140	1000	1071	1414	1871	3029	3886
135047	06	78	1000	1103	1692	2233	3949	5231
135052	06	89	1000	1079	1135	1393	2022	2461
137047	06	856	1000	1068	1169	1403	1922	2289
137048	06	167	1000	1132	1802	2611	4749	6521
137049	06	523	1000	973	1463	2034	3400	4499
137055	06	1479	1000	604	932	1305	2133	2757

(Continued)

BEST DOCUMENT AVAILABLE

Table 15. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c]					
			1976	1980	1990	2000	2020	2040
137062	06	67	1000	1060	1433	1940	3104	3940
138047	06	365	1000	1093	1718	1449	1222	1030
138048	06	2226	1000	1187	1748	2505	4512	6090
138049	06	2848	1000	978	1344	1851	3003	3887
138052	06	3266	1000	988	582	389	214	118
138054	06	733	1000	1050	1438	1944	3239	4265
138055	06	4778	1000	631	883	1191	1868	2361
138062	06	5896	1000	1085	1502	1983	2912	3486
138064	06	1302	1000	1115	1620	2290	4008	5413
138066	06	5124	1000	993	1106	1334	1833	2233
138068	06	78	1000	897	1256	1526	2231	3167
138115	06	1930	1000	919	1280	1784	2865	3709
140047	06	234	1000	1094	3654	7919	11786	16043
140049	06	11	1000	1091	1455	1727	2636	3182
140052	06	1961	1000	1095	956	720	473	311
140054	06	11	1000	1091	1455	1727	2636	3182
140055	06	50	1000	620	800	1020	1480	1820
140062	06	712	1000	1087	1479	2065	3593	4805
140066	06	970	1000	1003	1106	1351	2764	3345
141047	06	8263	1000	1098	1541	2173	3475	4323
141048	06	101	1000	1168	1743	2673	5297	7267
141049	06	189	1000	974	1365	2164	3571	4910
141050	06	156	1000	1006	1410	1962	3429	4558
141052	06	4067	1000	1026	1046	919	455	225
141054	06	1134	1000	1049	1480	2073	3605	4814
141062	06	2928	1000	1087	1557	2283	4996	7307
141064	06	426	1000	1124	1678	2441	4554	6246
141066	06	3154	1000	990	1159	1495	2233	2819
141068	06	100	1000	950	1110	1410	2150	2360
141115	06	1013	1000	916	1394	2003	3369	4492
143047	06	190	1000	1142	2068	2763	4421	5621
143048	06	11	1000	1182	1727	2636	4818	6727
143049	06	22	1000	955	1273	1682	2773	3545
143052	06	660	1000	1074	1008	1147	1470	1667
143055	06	11	1000	636	818	1182	1727	2182
143062	06	270	1000	1089	1581	2237	3963	5348
143064	06	22	1000	1091	1500	2045	3773	5091
143066	06	22	1000	1000	1182	1455	2182	2682
143115	06	10	1000	1000	1500	2100	3400	4500
144047	06	60	1000	1100	1583	2383	4400	6017
144049	06	11	1000	1000	1273	1636	2636	3364
144052	06	260	1000	1092	1219	1423	1927	2258
144054	06	11	1000	1091	1364	1818	2909	3818
144066	06	64	1000	1016	1141	1391	1938	2344

(Continued)

Table 15. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c]					
			1976	1980	1990	2000	2020	2040
915054[d]	06	22	1000	1000	1409	1909	3045	3909
915055[d]	06	500	1000	606	930	1266	2002	2540
915062[d]	06	316	1000	1073	1193	1475	2180	2712
915115[d]	06	30	1000	900	1400	1900	3033	3867

a. The first three digits indicate the BEA of origin; the last three digits indicate the BEA of destination.

b. Hundreds of tons.

c. Growth rates are reported such that 1,000 equals the index value reported in the third column.

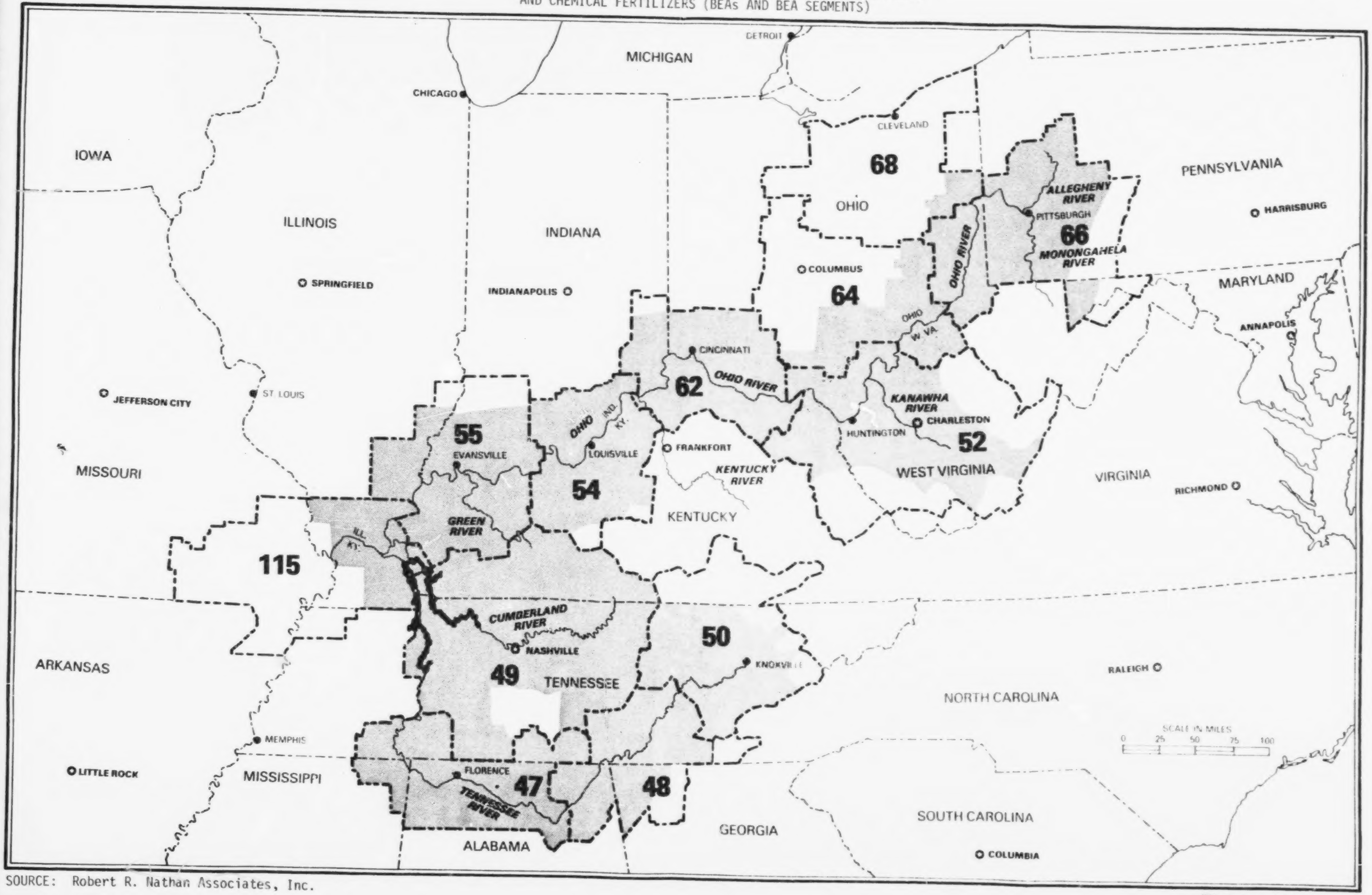
d. BEA 915 refers to counties of BEA 115 which are origins and destinations of waterborne movements which are shipped from and to points on the Mississippi River.

Source: Robert R. Nathan Associates, Inc.

V. APPENDIX

BEST DOCUMENT AVAILABLE

MAP A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR CHEMICALS AND CHEMICAL FERTILIZERS (BEAs AND BEA SEGMENTS)


DETROIT
MICHIGAN
CHICAGO
CLEVELAND
68
IOWA
OHIO
PENNSYLVANIA
ALLEGHENY RIVER
PITTSBURGH
66
MONONGAHELA RIVER
HARRISBURG
ILLINOIS
INDIANA
COLUMBUS
OHIO RIVER
SPRINGFIELD
INDIANAPOLIS
64
MARYLAND
OHIO
W. VA.
ANNAPOLIS
CINCINNATI
62
OHIO RIVER
KANAWHA RIVER
ST. LOUIS
JEFFERSON CITY
OHIO
IND.
KY.
HUNTINGTON
CHARLESTON
55
LOUISVILLE
FRANKFORT
52
EVANSVILLE
KENTUCKY RIVER
MISSOURI
54
WEST VIRGINIA
VIRGINIA
RICHMOND
KENTUCKY
GREEN RIVER
ILL.
KY.
115
CUMBERLAND RIVER
50
NASHVILLE
ARKANSAS
KNOXVILLE
49
TENNESSEE
RALEIGH
NORTH CAROLINA
SCALE IN MILES
0
25
50
75
100
MEMPHIS
LITTLE ROCK
MISSISSIPPI
FLORENCE
47
48
TENNESSEE RIVER
GEORGIA
SOUTH CAROLINA
ALABAMA
COLUMBIA

SOURCE: Robert R. Nathan Associates, Inc.

▨ Primary Study Areas

Table A-1. Ohio River Basin: Primary Study Areas for Chemicals and Chemical Fertilizers (BEAs and BEA segments)

BEA 47: Huntsville, AL

- Colbert, AL
- Franklin, AL
- Lauderdale, AL
- Lawrence, AL
- Limestone, AL
- Madison, AL
- Marshall, AL
- Morgan, AL
- Alcorn, MS
- Tishomingo, MS
- Franklin, TN
- Hardin, TN
- Lincoln, TN
- McNairy, TN
- Wayne, TN

BEA 48 (segment): Chattanooga, TN

- DeKalb, AL
- Jackson, AL
- Catoosa, GA
- Chattooga, GA
- Dade, GA
- Walker, GA
- Whitfield, GA
- Bledsoe, TN
- Bradley, TN
- Grundy, TN
- Hamilton, TN
- Marion, TN
- McMinn, TN
- Meigs, TN
- Polk, TN
- Rhea, TN
- Sequatchie, TN

BEA 49 (segment): Nashville, TN

- Allen, KY
- Barren, KY
- Butler, KY
- Christian, KY
- Clinton, KY
- Cumberland, KY
- Edmonson, KY
- Logan, KY
- Metcalfe, KY
- Monroe, KY
- Simpson, KY
- Todd, KY
- Trigg, KY
- Warren, KY
- Benton, TN
- Cannon, TN
- Cheatham, TN
- Clay, TN
- Coffee, TN
- Davidson, TN
- DeKalb, TN
- Dickson, TN
- Giles, TN
- Hickman, TN
- Houston, TN
- Humphreys, TN
- Jackson, TN
- Lawrence, TN
- Lewis, TN
- Macon, TN
- Maury, TN
- Montgomery, TN
- Overton, TN
- Perry, TN
- Pickett, TN
- Putnam, TN
- Robertson, TN
- Rutherford, TN
- Smith, TN
- Stewart, TN
- Sumner, TN
- Trousdale, TN
- Van Buren, TN
- Warren, TN
- White, TN
- Williamson, TN
- Wilson, TN

BEA 50 (segment): Knoxville, TN

- Anderson, TN
- Blount, TN
- Campbell, TN
- Cumberland, TN
- Fentress, TN
- Grainger, TN
- Jefferson, TN
- Knox, TN
- Loudon, TN
- Monroe, TN
- Morgan, TN
- Roane, TN
- Scott, TN
- Sevier, TN
- Union, TN

(Continued)

Table A-1 (continued).

BEA 52 (segment): Huntington, WV
- Boyd, KY
- Carter, KY
- Elliott, KY
- Greenup, KY
- Lawrence, KY
- Rowan, KY
- Gallia, OH
- Lawrence, OH
- Meigs, OH
- Scioto, OH
- Boone, WV
- Cabell, WV
- Clay, WV
- Fayette, WV
- Greenbrier, WV
- Jackson, WV
- Kanawha, WV
- Lincoln, WV
- Mason, WV
- Nicholas, WV
- Putnam, WV
- Raleigh, WV
- Roane, WV
- Sumners, WV
- Wayne, WV

BEA 54 (segment): Louisville, KY
- Clark, IN
- Crawford, IN
- Floyd, IN
- Harrison, IN
- Jefferson, IN
- Orange, IN
- Scott, IN
- Washington, IN
- Breckenridge, KY
- Bullitt, KY
- Grayson, KY
- Hardin, KY
- Henry, KY
- Jefferson, KY
- Meade, KY
- Nelson, KY
- Oldham, KY
- Shelby, KY
- Spencer, KY
- Trimble, KY
- Washington, KY

BEA 55 (segment): Evansville, IN
- Caldwell, KY
- Crittenden, KY
- Daviess, KY
- Hancock, KY
- Henderson, KY
- Hopkins, KY
- McLean, KY
- Muhlenberg, KY
- Ohio, KY
- Union, KY
- Webster, KY
- Edwards, IL
- Gallatin, IL
- Hamilton, IL
- Saline, IL
- Wabash, IL
- White, IL
- Dubois, IN
- Gibson, IN
- Perry, IN
- Pike, IN
- Posey, IN
- Spencer, IN
- Vanderburgh, IN
- Warrick, IN

BEA 62 (segment): Cincinnati, OH
- Dearborn, IN
- Franklin, IN
- Ohio, IN
- Ripley, IN
- Switzerland, IN
- Boone, KY
- Bracken, KY
- Campbell, KY
- Carroll, KY
- Fleming, KY
- Gallatin, KY
- Grant, KY
- Kenton, KY
- Lewis, KY
- Mason, KY
- Owen, KY
- Pendleton, KY
- Robertson, KY
- Adams, OH
- Brown, OH
- Butler, OH
- Clermont, OH
- Clinton, OH
- Hamilton, OH
- Highland, OH
- Warren, OH

(Continued)

Table A-1 (continued).

BEA 64 (segment): Columbus, OH
  Athens, OH
  Guernsey, OH
  Hocking, OH
  Jackson, OH
  Morgan, OH
  Noble, OH
  Pike, OH
  Vinton, OH
  Washington, OH
  Pleasants, WV
  Ritchie, WV
  Wirt, WV
  Wood, WV

BEA 66 (segment): Pittsburgh, PA
  Garrett, MD
  Belmont, OH
  Harrison, OH
  Jefferson, OH
  Monroe, OH
  Allegheny, PA
  Armstrong, PA
  Beaver, PA
  Butler, PA
  Clarion, PA
  Fayette, PA
  Greene, PA
  Indiana, PA
  Washington, PA
  Westmoreland, PA
  Brooke, WV
  Hancock, WV
  Marshall, WV
  Ohio, WV
  Tyler, WV
  Wetzel, WV

BEA 68 (segment): Cleveland, OH
  Carroll, OH
  Columbiana, OH

Table A-1 (continued).

BEA 115 (segment): Paducah, KY
  Hardin, IL
  Johnson, IL
  Massac, IL
  Pope, IL
  Pulaski, IL
  Union, IL
  Ballard, KY
  Calloway, KY
  Graves, KY
  Livingston, KY
  Lyon, KY
  Marshall, KY
  McCracken, KY

Source: Robert R. Nathan Associates, Inc.

Table A-2. Chemicals and Chemical Fertilizers: Listing of Other Industrial Chemicals, by Waterborne Commerce Statistics Classification (WCSC) Code

WCSC 2811: Crude products from coal tar, petroleum, and natural gas, except benzene and toluene

Ammoniacal gas liquors and spent oxide produced in coal gas purification.

WCSC 2813: Alcohols

Glycerine, refined
Ethylene glycol
Glycol ethers
Propylene glycol
Diethylene glycol and triethylene glycol
Polyethylene glycol
Polypropylene glycol
Methanol, including natural
Synthetic alcohols, chemically defined, monohydric, nec.
Ethyl alcohol
Fatty alcohols, chemically defined, C-8 and above range
Propyl alcohol (propanol)
Alcohols, nec., including polyhydric
Butanol or butyl alcohol
Glycols, nec.
Alcohol, mixtures, C-6 through the C-10 range, monohydric

WCSC 2819: Basic chemicals and basic chemical products, nec.

Phenol or carbolic acid
Isophthalic acid
Coal tar and other cyclic intermediate acids, nec.

(Continued)

Table A-2. (Continued)

WCSC 2819 (Continued)

Aldrin-toxaphene group of insecticides
Polychor insecticides, nec.
Parathion and methyl parathion
Organic phosphate insecticides, nec.
Rodenticides, nec.
Disinfectants, deodorants and germicides
Insecticides, nec. and agricultural chemicals, nec.
Fumigants (soil, grain and industrial)
Soil conditioners
Anethole
Chemicals for flavor and perfumery use, nec.
Chemicals as antiknock agents, excluding preparations
Papain
Rennet
Enzymes, nec.
Photographic chemicals, cyclic
Miscellaneous cyclic chemical products, nec.
Butylene
Acetylene
Ethylene
Propylene
Glycerine, crude
Alcohol mixtures above the C-10 range, monohydric
Methyl ethyl ketone
Acetone
Methyl isobutyl ketone
Formaldehyde and other aldehydes and ketones
Butyl acetate
Ethylene amines, except ethylene diamine
Ethylene diamine methylamines
Ethanolamines
Mino, DI, and TRI-ethylene, propylene and butylene, monamines
Amines and hydroxy amines, nec.
Monosodium glutamate and products
Chemicals as collecting reagents for concentration of ores, metals, or minerals, nec.
Caprolactam monomer
Methyl methacrylate
Ethyl acrylate monomer
Butyle, 2-ethyl hexyl and methyl acrylate monomer
Isoprene
Vegetable lecithim
Acetic acid
Maleic anhydride
Acids and anhydrides, nec.
Chloroform

(Continued)

Table A-2. (Continued)

WCSC 2819 (Continued)

Sodium hydroxide - caustic soda-solid
Sodium hydroxide - caustic soda-liquid
Potassium hydroxide
Sodium peroxide
Oxides, hydroxides and peroxides of strontium, barium, or magnesium
Aluminum oxide
Aluminum hydroxide
Artificial corundum or fused aluminum
Chromium oxides, anhydrides and hydroxides, pigment grades
Chromium oxides, anhydrides and hydroxides, except pigment grades
Tin oxides
Antimony oxide
Zirconium oxide
Lithium hydroxide
Pigment grade inorganic bases, metallic oxide, hydrox and perox, except white pigment, nec.
Inorganic bases and metallic oxides, hydroxides, and peroxides, nec.
White pigments, inorganic, nec.
Pigments, inorganic, except white, nec.
Aluminum sulfate
Aluminum compounds, nec.
Sodium hydrosulfite
Sodium tripolyphosphate or triphosphate
Sodium phosphate
Sodium bichromate and chromate
Sodium cyanide
Sodium sulfate, crude and refined
Sodium borates, refined
Sodium bicarbonate
Sodium compounds, nec., excluding bleach alkalies and sodium carbonate, synthetic and natural
Potassium compounds, nec.
Sodium carbonate or soda ash
Alkalies, nec.
Liquid air
Ammonium paratungstate
Ammonium compounds, nec. except ammonium nitrat, ammonium sulfonitrat and ammonium sulfate
Bleaching compounds, inorganic, nec.
Silicon carbide, crude and in grains
Tungsten carbide powder
Carbide abrasives, nec., sized grains, powders and flour
Insecticides, fumigants, and inorganic except formul, prep and chem for retail sale

(Continued)

[redacted]

Table A-2. (Continued)

WCSC 2819 (Continued)

Ethylene dichloride
Carbon tetrachloride
Trichloroethylene
Methylene chloride
Vinyl chloride monomer
Perchloroethylene
Chlorinated hydrocarbons, nec.
Organo-fluorine compounds, nec.
Citric acid
Fatty acids
Vinyl acetate monomer
Acrylonitrile monomer
Butadiene monomer
Met salts of fat acids (metal soaps) excluding det soaps, plasticizers and paint and varn driers
Miscellaneous organic chemicals, except cyclic, nec.
Oxygen
Nitrogen
Helium and mixtures containing helium
Hydrogen and rare gases, nec.
Hydrochloric and chlorosulforic acids
Boric acid
Phosphoric acid, fertilizer grade
Phosphoric acid, nec.
Inorganic acids, nec.
Carbon dioxide, nitrous oxide, and carbon monoxide
Oxygen compounds of non-metals or metalloids, nec.
Halides, oxyhalides, and other halogens of non-metals or metalloids
Sulfides of non-metals or of metalloids
Zinc oxides and peroxide, pigment grades
Zinc oxides and peroxide, except pigment grades
Manganese oxides, pigment grade
Manganese oxides, except pigment grade
Iron oxides and hydroxides, pigment grade
Iron oxides and hydroxides, except pigment grade
Cobalt oxides and hydroxides, pigment grade
Cobalt oxides and hydroxides, except pigment grade
Titanium dioxide, pigment grade
Titanium oxides, except pigment grade
Ammonia, anhydrous or in aqueous solution, except fertilizer grade
Lead oxides, pigment grade
Lead oxides, except pigment grade
Ammonia, anhydrous or in aqueous solution, fertilizer grade

(Continued)

Table A-2. (Continued)

WCSC 2819 (Continued)

Detergent alkylate - dcecylbenzene
Higher alkylbenzenes, nec.
Cyclohexane
Toluene Dll socyanates
Phthalic acid and anhydrides
Dimethyl terephthalate
Ethylbenzene
Tetrahydrofuran
Resorcinol
Dichlorobenzene
Cumene
Ortho-Xylene
Para-Xylene
Other coal tar and cyclic chemical inter except acids, nec.
Anti-infective sulfonamide drugs, in bulk
Acetylsalicylic acid or aspirin, in bulk
Analygesics, antipyretics, and anti-inflammatory agents, nec., in bulk
Antihistamines, in bulk
Anti-infective agents, nec., in bulk
Autonomic drugs, in bulk
Drugs affecting the central nervous system, nec., in bulk
Skeletal muscle relaxants' and tranquilizers, nec., in bulk
Synthetic organic medicinal chemicals, nec., in bulk
Rubber compounding chemicals, except cyclic
Rubber accelerators, cyclic
Rubber antioxidants, cyclic
Rubber compounding chemicals, cyclic
Plasticizers, except cyclic
Dioctyl phthalates
Phthalete anhydride ester plasticizers
Plasticizers, cyclic, nec.
Fungicides
Herbicides, 2, U-D, and 2, 4, 5-T, including salts and esters thereof, as parent acid
Herbicides of pentachlorophenate and of mercury
Herbicides, nec.
Dichlorodiphenyl trichloroethane (DDT)

(Continued)

Table A-2. (Continued)

WCSC 2819 (Continued)

Fungicides - inorganic forms of copper, sulfur and metallic chemicals except prepared electricity for retail sale
Herbicides and defoliants, inorganic, except formulation prepared and chemical for retail sale
Calcium carbonate, precipitated, except pigment grade
Calcium chloride
Dicalcium phosphate
Inorganic chemicals, nec., except medicinals
Inorganic medicinal chemicals, nec., in bulk

WCSC 2891: Miscellaneous Chemical Products

Chlorine
Sulfur, processed, ground and screened, refined, sublimed, precipitated, etc.
Quicksilver or mercury
Carbon black, contact - include channel
Carbon black, furnace, except lampblack
Carbon, except gas carbon, and other
Blacks of carbon, including lampblack
Elemental phosphorus
Selenium metal
Chemical elements, nec.
Inks, printing
Orange oil
Lemon oil
Citrus oils, nec.
Peppermint oil
Spearmint oil
Cedarwood oil, clove oil and nutmeg oil

Source: Prepared by Robert R. Nathan Associates, Inc. from U.S. Foreign Trade Statistics Classification of Foreign Commodities Exported from U.S.

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Ohio Valley Improvement Association, Cincinnati, Ohio

Tennessee Valley Authority, National Fertilizer Development Center, Muscle Shoals, Alabama

U.S. Department of Agriculture, Agricultural Stability and Conservation Service, Washington, D.C.

C. Industrial Sources

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Allied Chemical, Southpoint, Ohio

Ashland Chemicals, Ashland, Kentucky

B.F. Goodrich, Calvert City, Kentucky

Diamond Shamrock, Mobile, Alabama

E.I. Du Pont de Nemours & Co., Inc., Wilmington, Delaware

FMC Corporation, S. Charleston, West Virginia

N-Ren, Eastern Division, Cincinnati, Ohio

PPG, Inc., Marshall City, West Virginia

Shell Oil Company, Houston, Texas

USS Chemical Company, Neville Island, Pennsylvania

Union Carbide Corporation, Charleston, West Virginia